POWER

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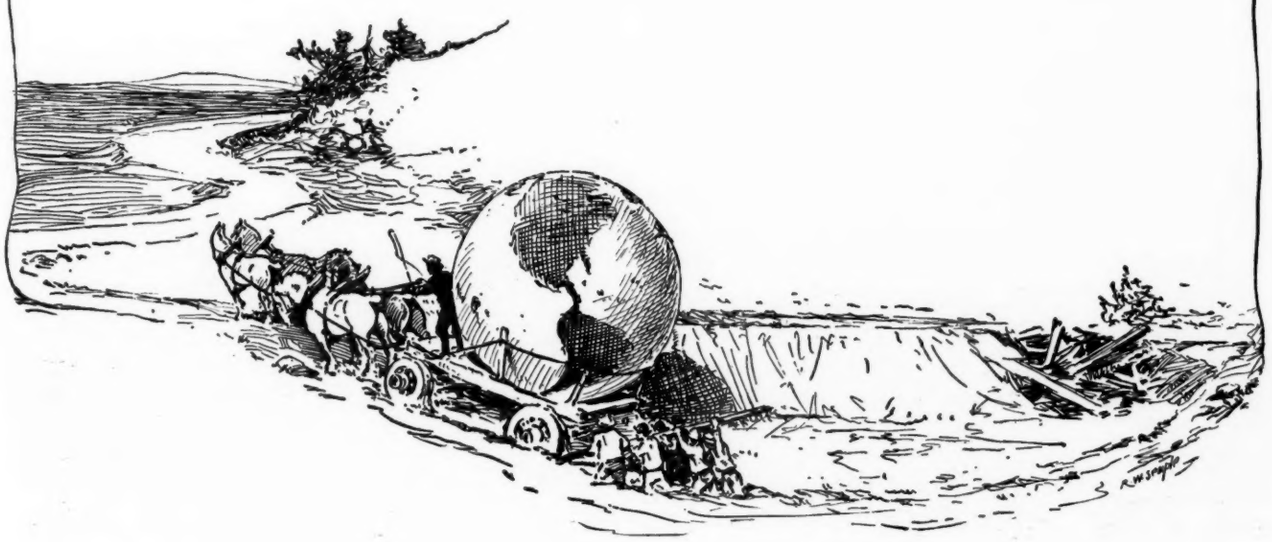
Now, All Together!

This old world has for some time been dragged along in the mire. While Europe can still see little but the mud, the Western Hemisphere is facing the light and is beginning again to feel solid ground. The bottom has been reached and safely passed, and the up grade is now being negotiated. All that is now required is lots of pushing, confidence and optimism to put industry on the smooth road. Concerted effort won the war; let the same spirit bring about readjustment.



Water Control on Hydro-Electric Systems

Operating Procedure for a Hydro-Electric System of Six Plants Utilizing a Combined Static-Head of 2,637 Feet—Description of Storage Reservoirs and Methods of Conveying Water to the Plants—Measurement of Evaporation from Reservoirs—Evaporation from One Reservoir Has Been as High as 39 Acre-Feet per Day

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IN THE State of California alone the estimated water-power resources are 9,250,000 hp., of which some 950,000 hp. is at present developed or under development. In California, as is common with most other mountain states, the precipitous nature of the watersheds results in torrential streams during the Spring season with consequent great waste of water. To make full use of such run-off, it is necessary to use storage and regulate its flow. Where existing lakes are not present to offer natural possibilities for effective and relatively cheap regulation of the run-off, it becomes necessary to build dams and form artificial reservoirs. Water impounded thus by artificial means has additional value, and the judicious use of such water from season to season in connection with hydro-electric generating systems, is an important, if not the most important, phase of the operation of any such system.

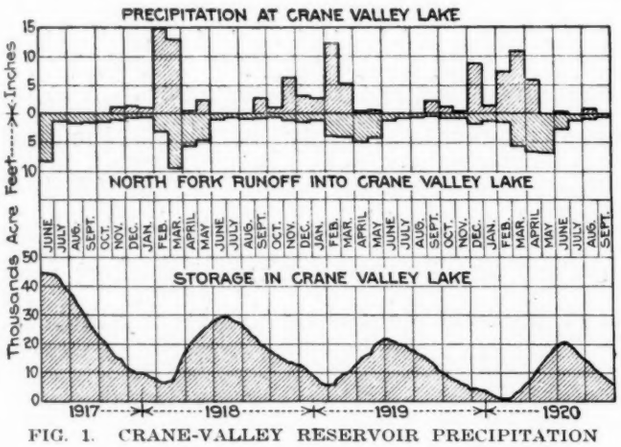


FIG. 1. CRANE-VALLEY RESERVOIR PRECIPITATION

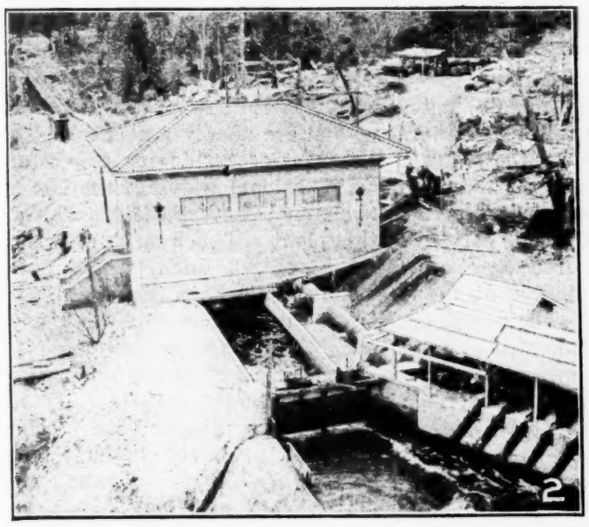
The San Joaquin Light and Power Corp., of Fresno, Cal., has in its Crane Valley system of reservoirs, waterways and power plants, probably as good an example as could be found of storage and regulation of water for electric generating purposes (see Figs. 2 to 8). At this particular locality in the Sierra Nevada Mountains, within a distance of 19 miles, representing a difference in elevation of 2,740 ft., are to be found six hydro-electric plants operating under a combined static head of 2,637 ft. All these plants use the same stored water; however, the three lower plants have their stored water supply augmented by the flow of other streams. The water supply for this chain of plants except the lowest one is derived from the North Fork of the San Joaquin River. This supply comes from the watersheds of two tributaries to the North Fork, the North and the South.

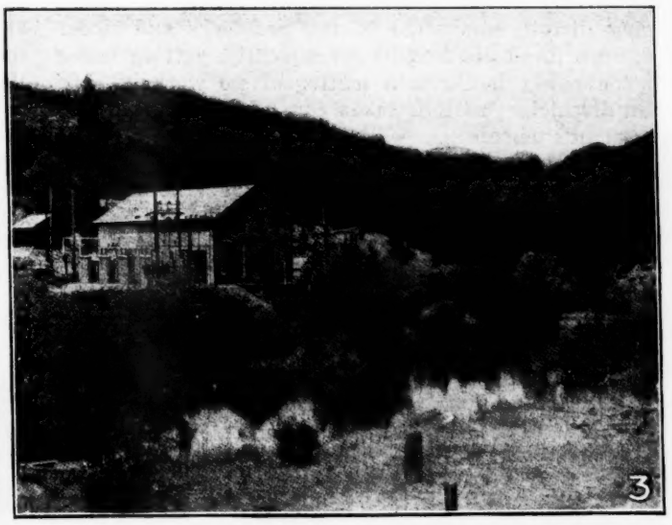
In 1912 the San Joaquin Light and Power Corp. completed the erection of a large dam at the site of a previously existing small crib dam in Crane Valley, the valley being part of the north fork of the stream. As completed, this dam has a total length on the top of 1,860 ft. The height above the lowest point of the canyon is 150 ft., the crest width of the earth-fill section is 30 ft. and of the rock-fill section, 15 ft. The reservoir formed by this dam is about five miles long and has an area of 1,200 acres when full. It impounds the run-off from 52 square miles adjoining the North Fork and eventually that of the 26 square miles of the South Fork, with the rebuilding of the Browns Creek flume. Fig. 1 shows the monthly precipitation at Crane Valley over several years and the resulting run-off. The storage curve shows the reservoir full at 45,000 acre-feet, for the last time in June, 1917, and attention is called to the record of the next three successive years, they being the contributory cause of the serious power shortage of the last year, not only in central California but in the whole state.

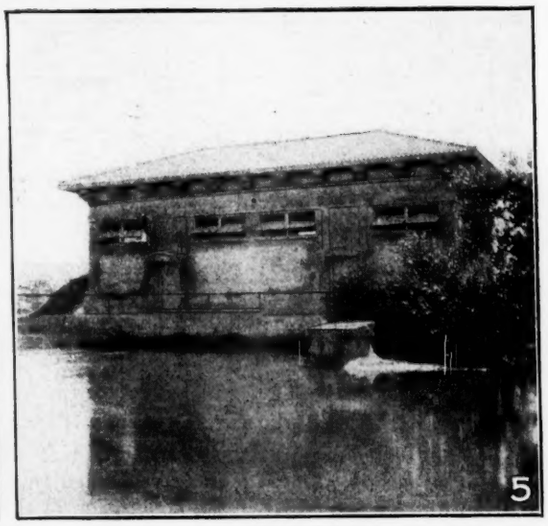
For controlling the outlet of water into the canal system a concrete tower was erected in the reservoir, outside the upper toe of the dam. This tower opens into a horizontal tunnel 722 ft. long, which is carried through the rock under the dam to the penstock of the first plant of the chain, directly at the foot of the dam. These gates are placed at different heights, so that by proper manipulation water may enter the tower from the surface only, at any elevation of the reservoir level.

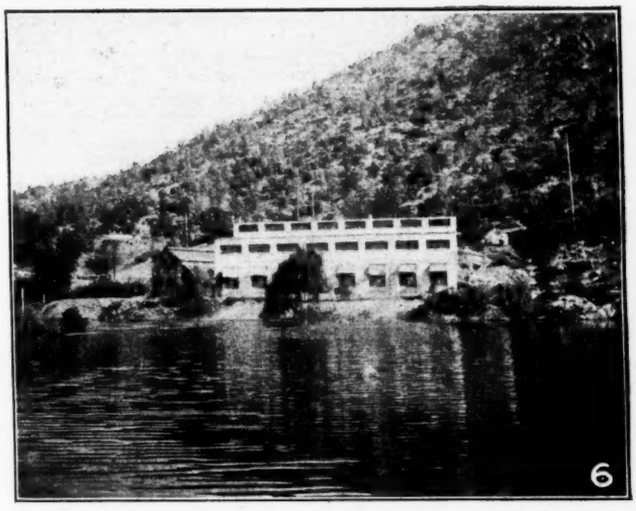
In Fig. 8 are shown the relative locations and elevations of the hydro plants using the Crane Valley storage, showing also the capacities of the various ditches and reservoirs. In the waterways of this group are represented practically all known methods of conveying water. In open ditches there are of metal lined and cemented, a total of 30,096 ft. and an additional 3,217 ft. in semicircular steel flume of the type suspended on cradles. This was the preponderant method until the Kerckhoff project (described in *Power*, Dec. 14, 1920) put tunnels in the lead, there now being a total of 44,790 ft. in tunnels. There is a combined length of 17,333 ft. of steel pipe line in the penstocks or pressure lines to the power houses, which range from 24 in. to 8 ft. in diameter. Of redwood stave pipe there is 975 ft., this being the one and only inverted siphon of the system.

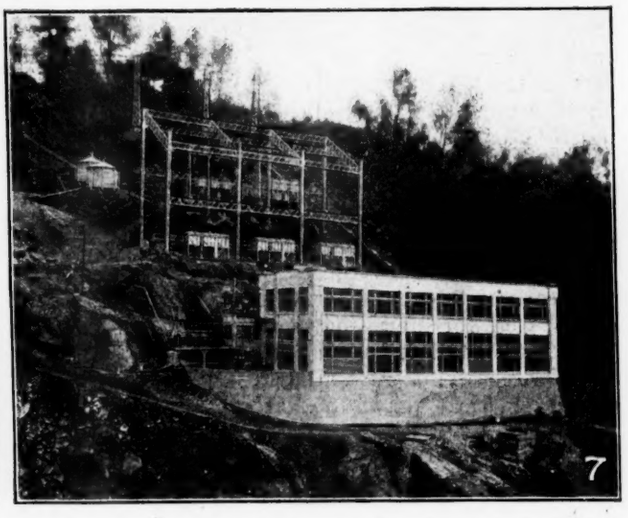
Exclusive of the stored water in the Crane Valley reservoir there is the additional capacity of 4,163 acre-feet available in the forebays and regulating reservoirs of this group of plants. It is this storage that makes possible the manipulation of the different plants to meet the load conditions of the day. The more important of these regulating reservoirs are the Kerckhoff Lake and the No. 2 reservoir. The former was created by the erection of a concrete dam of the constant-angle arch type across the canyon of the San Joaquin River,











FIGS. 2 TO 7. POWER PLANTS ON THE HYDRO-ELECTRIC SYSTEM OF THE SAN JOAQUIN LIGHT AND POWER CORPORATION ON THE SAN JOAQUIN RIVER, CALIFORNIA

Fig. 2—Crane Valley Power house, containing one 1,740-hp. single-runner reaction-type turbine, driving a 1,000-kva. induction-type alternator. Fig. 3—No. 3 power house in which there are installed two 1,400-hp. double tangential impulse-type turbines, driving 1,200-kva. synchronous alternators. Fig. 4—Power house No. 2, containing one 5,250-hp. horizontal reaction-type turbine with double discharge, and driving a 3,000-kva. synchronous alternator. Fig. 5—Power house No. 1A, where there is installed one 600-hp. single-runner reaction-type turbine, driving a 425-kva. induction-type alternator. Fig. 6—Power house No. 1, which contains four 6,100-hp. single tangential impulse-type 400-r.p.m. turbines, each driving a 4,000-kva. synchronous alternator, making a total capacity in this plant of 24,400 hp. Fig. 7—Kerckhoff power house. There are installed in this plant three 15,000-hp. vertical single-runner reaction-type turbines operating at 360 r.p.m., and driving 14,200-kva. synchronous alternators.

being completed in July, 1920. This lake is virtually the forebay of the Kerckhoff power house, the tunnel being directly connected to the penstocks and under pressure its entire length; consequently, getting water to the power house is a matter of no worry to the load dispatcher, as it is taken care of automatically by the plant's demands.

The No. 2 reservoir was formed in 1915 by the construction of a concrete dam across the channel

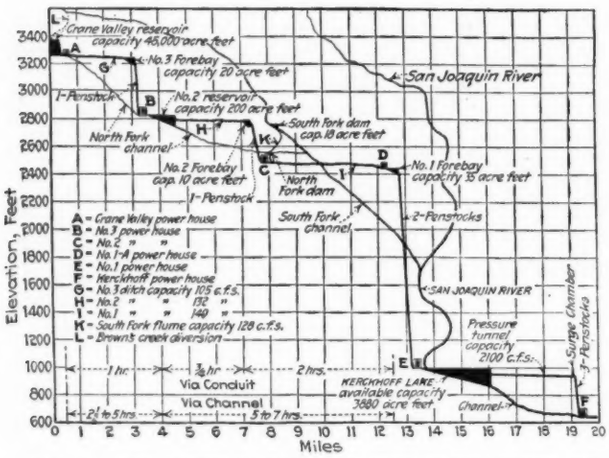

Crane Valley reservoir capacity 46,000 acre feet
No. 3 Forebay capacity 20 acre feet
San Joaquin River
No. 2 reservoir capacity 200 acre feet
South Fork dam cap. 18 acre feet
North Fork channel
No. 2 Forebay cap. 10 acre feet
No. 1 Forebay capacity 35 acre feet
North Fork dam
South Fork channel
2-Penstocks
A = Crane Valley power house
B = No. 3 power house
C = No. 2 " "
D = No. 1-A power house
E = No. 1 power house
F = Kerckhoff power house
G = No. 3 ditch capacity 105 c.f.s.
H = No. 2 " " 132 "
I = No. 1 " " 140 "
K = South Fork flume capacity 128 c.f.s.
L = Brown's creek diversion
SAN JOAQUIN RIVER
Pressure tunnel capacity 2100 c.f.s.
Surge Chamber
3-Penstocks
1 hr
3/4 hr
2 hrs.
Via Conduit
KERCKHOFF LAKE available capacity 3080 acre feet
Via Channel
2 1/2 to 5 hrs
5 to 7 hrs
Channel
Elevation, Feet
Miles

FIG. 8. RELATIVE LOCATIONS AND ELEVATIONS OF PLANTS USING CRANE-VALLEY STORAGE

of the North Fork about three-quarters of a mile below No. 2 power house. Built in one end of this dam is a spillway which is normally kept closed by flashboards and opened only during heavy rainstorms when the reservoir happens to be full. In the base of this dam there are waste gates which may be used to bypass the No. 2 power house, Fig. 4, the flow being determined from discharge curves. At the end of the dam opposite to the spillway is the motor-operated gate which admits water to No. 2 ditch. The operation of this gate is remotely controlled from No. 3 power house, Fig. 3, there being as a safeguard, travel limit stops which shut down the motor. In the No. 2 ditch just below the dam at the official measuring station of this ditch, is placed a pressure gage, which transmits electrically to the No. 3 power house, the water level in the ditch. For this measuring station, as for all others, there has been a rating table prepared by making actual velocity measurements at different levels, with a standard current meter and calculating from the cross-section the flow in cubic feet per second.

At each of the power houses there is one or another sort of gage for indicating the water level in the forebay. The load dispatcher has a capacity curve for each of the forebays and regulating reservoirs, showing the capacity in acre-feet of each at all elevations or gage levels. He has also a very complete set of curves on the Crane Valley reservoir, showing the area at all elevations as well as the capacity. The gage at this place is made of surveyor's level rods attached to the wall of the gate tower and supplemented with a recording meter actuated by a float. As the water level varies throughout the year, this recording meter is moved up or down the tower just before the water level gets out of the range of the instrument.

At the foot of the Crane Valley dam is located the Crane Valley power house, Figs. 2 and 8, an induction-generator installation, requiring an attendant only to put the unit on the line and to make load changes whenever necessary. In the penstock of this plant, which is connected directly with the pressure-outlet tunnel from the reservoir, are twelve pipes controlled each by a 10-in. hand-operated valve. These discharge water into the tailrace of the plant and are simply a means of bypassing the plant in the event of turbine or generator trouble, or to send down additional water to the No. 2 reservoir by the natural channel if ever necessary. The block loads carried at this plant are such as to give the required flow of water in No. 3 ditch, which flow is checked at the measuring station in the ditch just below the power house. The performance of this plant is indicated to some extent by an ammeter at the No. 3 power house, which is energized by a high-potential current transformer in the main line to the plant. Thus, the operator at No. 3 would know at any time of the Crane Valley plant tripping off the line during a system disturbance.

In Fig. 8 is also shown the time in hours required for water to reach the various plants either by conduit or by natural channel, which is of some importance to the dispatcher in considering the necessary changes in flow during the day. It will be noticed that the capacity of No. 2 ditch is in excess of that of No. 3 ditch. This makes apparent the value of No. 2 regulating reservoir, as No. 2 ditch may be run full most of the day if necessary and be shut off at night, and the reservoir filled

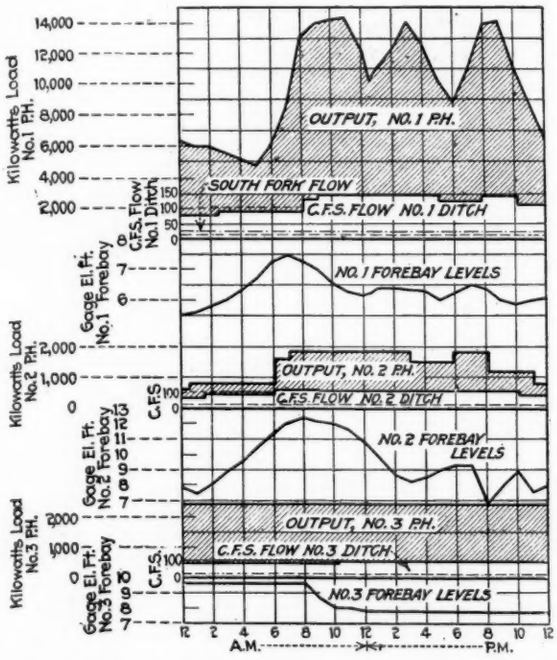


FIG. 9. RECORD OF DAY'S OPERATION OF PLANTS USING CRANE-VALLEY STORAGE BEFORE KERCKHOFF PLANT WAS ADDED

by running the Crane Valley and No. 3 plants as long as necessary. Not all the water in No. 2 reservoir is available through No. 2 plant; however, it is available to Nos. 1 and 1-A plants by way of the natural channel and North Fork, diversion dam to No. 1 ditch. It will be noticed also that the capacity of No. 1 ditch is in excess of that of No. 2 ditch. In this connection attention is called to the South Fork flume which conveys the flow of the South Fork stream, not to exceed

128 cu.ft.-sec. to the head of No. 1 ditch, which is at the North Fork diversion dam. Any flow in excess of 128 cu.ft.-sec. is discharged over the South Fork dam into the natural channel, thence to the main river and Kerckhoff Lake. The flow of the South Fork stream varies considerably during the year, dropping from several hundred to as low as 5 cu.ft.-sec. during the late summer. During heavy rains the gage at the measuring

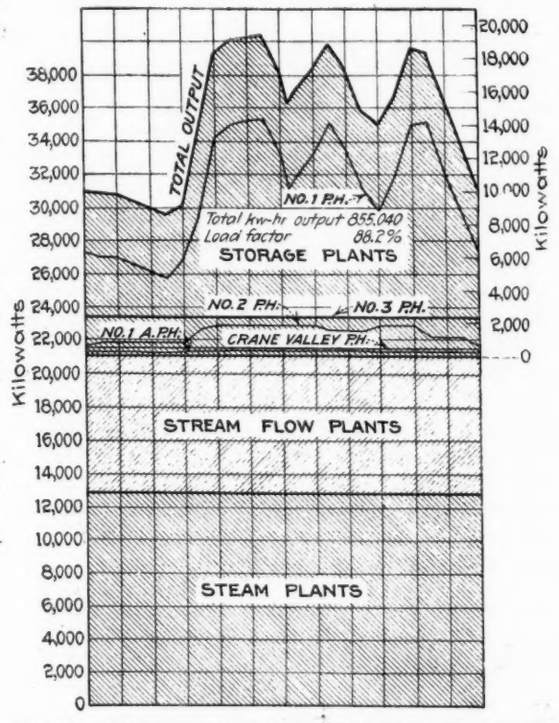


FIG. 10. WATER-FLOW AND LOAD CURVES OF THE DIFFERENT PLANTS ON THE SYSTEM

station in No. 1 ditch at No. 2 power house has to be watched continually so that load changes can be made promptly at No. 2 power house to prevent running the ditch over and endangering it from washout. With the rebuilding of the Browns Creek flume, which was burned out a number of years ago, the South Fork will be diverted into the Crane Valley reservoir where it will be more valuable, being available through three more plants than at present.

Water in No. 1 ditch, just before reaching No. 1 forebay, passes either through or around No. 1-A power house, Fig. 5, which is another induction-generator installation. This power house requires the attention of an attendant only to put it on the line, as it makes load changes automatically through float control switches in the flume at the head of its penstock. If the plant is tripped off the line for any reason, it shuts down and the water flows over a weir at the head into a bypass flume and thence into No. 1 forebay. The output of this plant is indicated by a wattmeter on the switchboard in No. 1 power house so that the operator at the latter plant can observe the performance of the plant above.

No. 1 power house, Fig. 6, until the recent completion of the Kerckhoff power house, had always been the governing plant on the system, consequently the dispatcher's problem was to operate the block load plants above in such a manner as to always have sufficient water in No. 1 forebay to meet the load demands, yet not so much that it would be necessary to waste any. The two penstocks at No. 1 power house are equipped with venturi meters, making possible the accurate measurement of the water used, which would otherwise be a laborious task owing to the varying loads at this, the governing plant. Each forebay has a spillway as a precautionary feature; however, in the last several years during the acute power situation, there has been little or no water spilled at any of these forebays. Having now the comparatively large capacity of the Kerckhoff Lake available, the Kerckhoff power house will be required to govern and thus to some extent simplify the problem of water control and regulation.

Converting Flow Figures to Acre-Feet

The method used in converting flow figures to acre-feet, in calculating the daily outflow from the Crane Valley reservoir, and from the forebays and regulating reservoirs over any period, is based on the fact that one cubic foot of water per second flowing for 24 hours is very nearly equal to two acre-feet, there being practically twice as many seconds in 24 hours as there are cubic feet in an acre-foot. Therefore, it follows that one cubic foot per second flowing for 12 hours is equal to one acre-foot, which applies for any rate of flow per second for any number of hours.

In connection with keeping up the records of run-off from the watersheds contributory to the Crane Valley reservoir, it is necessary to know the inflow each day. Since there are several small streams besides the North Fork flowing into this reservoir, it is not practical to measure the flow of all these streams each day and use their total, therefore it is determined in another manner.

As soon as the dispatcher has time after midnight, he calculates the outflow from the reservoir by the method previously outlined, using the rating curve of the measuring station in No. 3 ditch near the dam, for each change made in the flow during the previous day. At about 7 o'clock in the morning he receives by telephone the midnight elevation or gage reading of the reservoir level, which is taken from the recording gage on the gate tower. Referring to his capacity curve, he notes the capacity at that particular elevation. This, in comparison with the capacity corresponding to the previous midnight reading, indicates immediately whether there has been a loss or a gain in the reservoir. If there has been a gain, then the inflow is represented by the sum of the outflow and the gain.

Calculating Loss Due to Evaporation

During those months of the year when evaporation is appreciable, the loss by evaporation is calculated daily and added to the outflow through the gate tower. To measure the evaporation, a galvanized-iron pan 7.45 ft. in diameter and 2 ft. deep, with a ¾-in. iron pipe rim, was made and placed in the reservoir near the gate tower. The pan is provided with a hook gage and filled up to this gage with water. A pail was made holding just enough water to raise the level 0.002 ft. when poured into the pan. Water is poured into the pan each morning to make up for that evaporated during the previous day, and account is taken of the number of pailfuls needed to bring the water in the pan back to the same level as shown by the gage. Having been telephoned the reservoir level and the number of pail-

fuls used, the dispatcher ascertains from his curve the area at that particular elevation and applies the formula,

Number of pails × *0.002* × *area of reservoir* = *acre-feet evaporation*

The daily evaporation from this reservoir has run as high as 39 acre-feet during the summer months, with the reservoir at the higher elevation—in the case mentioned, 110 ft. Some conception may be gained of the enormous quantities of water evaporated daily by thinking of it in more familiar terms. For instance, a train of 1,061 tank cars, each of 12,000 gal. capacity, would be required to contain 39 acre-feet, the quantity lost in a single day.

Record of Plant Operation

In Fig. 9 is shown an actual day's operation in the early summer before the Kerckhoff power house had been added to the system. The operation of the plants using the Crane Valley storage is clearly shown, the hourly loads of each of these plants being plotted above the stream-flow plants as a base, against the kilowatt scale at the right margin. Briefly, the Crane Valley plant was run at practically a constant load, sufficient to supply the No. 3 power house, that it in turn might run at a constant load to keep sufficient water in the No. 2 regulating reservoir. The load at the No. 2 power house was varied throughout the day to supply the required quantity of water to the No. 1 forebay at the time it was needed. The detail operation of the three plants most affecting the water regulation is shown in Fig. 10 along with the curves showing the variation of their respective forebays, which curves it will be noticed have a general resemblance to the load curve. The flow curves shown in this figure represent the changes in flow at the respective forebays. It will be noticed that the No. 1 ditch flow curve is virtually a reproduction of the load changes at the No. 2 power house, the changes at the No. 1 forebay occurring approximately two hours later. There was little or no variation in the No. 2 reservoir level on this day, so it was not plotted.

Operators and Dispatchers Co-operate

Needless to say, the successful control of this water supply to meet the day's power requirements would not be possible without thorough co-operation between the operators and dispatchers, and among the dispatchers themselves. These latter men, who are constantly busy with the many affairs of the system, must at all times bear in mind the water situation and be on the alert to investigate any inconsistent reading turned in, which might indicate an order carried out improperly or entirely forgotten or might even indicate a ditch broken and washed out. Having before him, draft curves of all the plants along with the capacity curves of the forebays and reservoirs, as well as the rating tables for all ditches and knowing about how the load will run throughout the day, the dispatcher is the one man in a position to manipulate these plants to meet successfully the demands of the day, and be properly set for the succeeding day's run.

Refrigeration Plant Troubles

By J. C. MORAN

PROBABLY the most foolish experience in correcting refrigerating-plant troubles I ever encountered was one where I had to travel about five hundred miles to remove a little wedge that had been left in the small space between the cap of the valve cage of a compressor and the top of the valve by an overhauling crew. Who had left it there or why, no one ever found out, but it was probably not done purposely because the crew that did the overhauling had to work overtime for nothing for a number of nights without being able to find the cause of the trouble. The engineer was so badly in need of the machine that it does not seem reasonable that he would do it purposely and then call in an outside man to locate the trouble. At any rate the wedge was there when we finally removed the cap from the valve cage.

A 100-ton machine of the same type had been running along in great shape for about a year when it suddenly lay down on the job and refused to do much more than 50 per cent of the work it had been doing before. It was an electrically driven outfit making ice, and this machine was handling the load alone so it was a simple matter to see that there was something radically wrong. Furthermore, one of the cylinders ran very hot and there was practically no frost on the section of the suction header leading to this side of the machine.

When the cylinder head was removed and an attempt was made to remove the false head for inspection and to inspect the interior of the machine, the crew found that they had a job on their hands. The false head is centered by a number of ribs that hold the head in its exact position. For some reason the head was jammed between these ribs so that it was impossible to move it.

Finally a block and tackle was rigged up, and after considerable pounding and hauling on the tackle the false head was pulled out. The piston was at the top of the stroke and when the false head was removed one of the screws that hold the suction valve cage in place was found lying partly across the top of the piston and partly across the seat of the false head. This is shown at *A* in the figure, in which *S* is the screw that caused the trouble.

As near as could be figured out, this screw had started to back out and, after pounding against the head for some time, it had stripped the threads and jumped out. It had then been caught between the piston and the false head when the piston came to the top of the stroke, and in some way it had glanced over so that it had slipped onto the seat of the false head and been caught there as the head was again forced down. In doing this it had also cracked a piece out of one of the ribs that center it in place and jammed it so that it was next to impossible to move it.

This of course left the false head off the seat with a considerable space between it and the seat, and there was little if any work done by this side of the machine. The best part of it, however, was that the men had heard it pounding for some time without paying any

attention to it, and the night engineer admitted that one night when he had been about half asleep there had been a terrific thump in the machine, but that he had assumed that it was a slug of liquid coming back and had paid no more attention to it because he had not noticed anything further the matter during the night. If you hear any unusual noises around your machines it is always the best policy to investigate the matter at once until you are sure that the trouble is not caused by anything that can result in damage of any sort.

Water in the Ammonia Charge

Some years ago I was called in to locate a case of water in the ammonia charge that had kept the power-plant crew, and everyone else they could bring into the plant to investigate the trouble, scratching their heads for more than a month. For some reason the plant failed to come up to expectations after it had been overhauled during the winter season. After investigating every possible place for the trouble, one man finally decided to test the ammonia charge, and to their surprise they found that it contained a large percentage of water.

Every part of the plant, including the condenser, the brine tank, and even the oil used for the compressor, was tested. Apparently everything was waterproof, so the entire charge was removed, the system blown out thoroughly, and a new charge put in. Fortunately, the plant was small and the expense of this operation was not very large.

About a month later the machine again showed symptoms of trouble, and after looking in the most likely places for the cause at first, they finally decided to test the ammonia. Again there were symptoms of water in the charge. The engineers were at their wits' end to account for this trouble, and while on the job erecting a near-by machine I was asked to come over and see if by any chance the others had overlooked any possible place where water could get into the ammonia system.

Well, I trapped around that system the best part of two days trying to find the trouble, when I finally happened to think of the water jacket on the compressor. The men laughed at me when I suggested this point, for the reason that they carried a suction pressure of 25 lb. and under no possible circumstances could they see how water could work in at this point.

Searching for the Leak

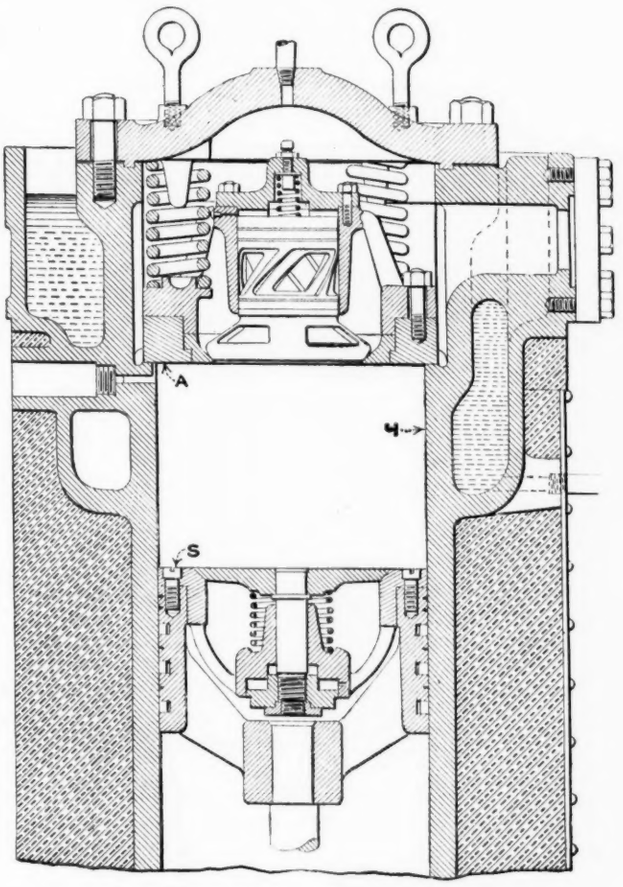
I had noticed, however, that they were in the habit of pumping down the system at least once every eight hours and generally they pumped down to about 5 to 10 in. of vacuum. I next tested their suction pressure gage and found that this was registering about 5 lb. high, so that instead of 5 to 10 in. of vacuum there was more nearly 10 to 20 inches.

Next, I tested the water jacket with litmus paper and found that this was loaded with ammonia. The next problem was to locate the leak, which I imagined to be quite simple, expecting to find some joint below the water level that was leaking.

After draining out the water and leaving the machine to dry out thoroughly I began testing with a sulphur stick for the leak. Of leaky joints there was none, and whenever I stuck the sulphur stick down into the water jacket it seemed to be full of ammonia fumes, no matter where I put it. Using litmus paper for testing did not help matters any. Finally we shut the machine down, first pumping it out thoroughly, and after a couple of hours we found that we could stick a sulphur stick down into the water jacket without finding any signs of ammonia.

While I investigated with the sulphur stick I had one of the men open up slowly on the suction valve to the machine. I could hardly believe my eyes when in passing the stick along the side of the cylinder from one point to another, a sudden cloud of smoke indicated an ammonia leak and it seemed to be coming directly through the side of the cylinder. This is just what it was doing.

There was a fairly large sandhole in the side of the cylinder, and during the winter, while boring out the



LOCATION OF COMPRESSOR TROUBLE

cylinder, the thin shell at this point had broken through, as indicated by *H* in the illustration. While the machine was in regular operation the ammonia leaked out through this hole, and every time they pumped down the water seeped through. While it did not amount to very much each time, after the performance had been gone through several times every day in the month, quite a considerable amount of water worked into the system.

The hole was plugged by drilling it out from the inside of the cylinder and threading a soft iron plug with pipe thread to fill it, a ¼-in. pipe thread being amply large. After the plug was screwed in absolutely solid it was cut off close to the cylinder wall and finished off with a file. No further trouble was experienced with it, and it is probably still there.

Electric Elevator Machinery—Cable and Sheaves

Methods of Attaching Winding Drum to Worm Gear—Gearing for Slow-Speed Machines—Cable Arrangements for Both Basement-Type and Overhead Machines—Method of Attaching Cables to Drums

By M. A. Meyers
Electrical Engineer, The Maintenance Company, New York City

ELECTRIC elevators may be divided into two general classes: Drum type, Fig. 1; and traction type, Fig. 2. In either type, with the exception of the direct-traction machine, the cast-iron spider of the bronze worm wheel has cast integral with it a flange

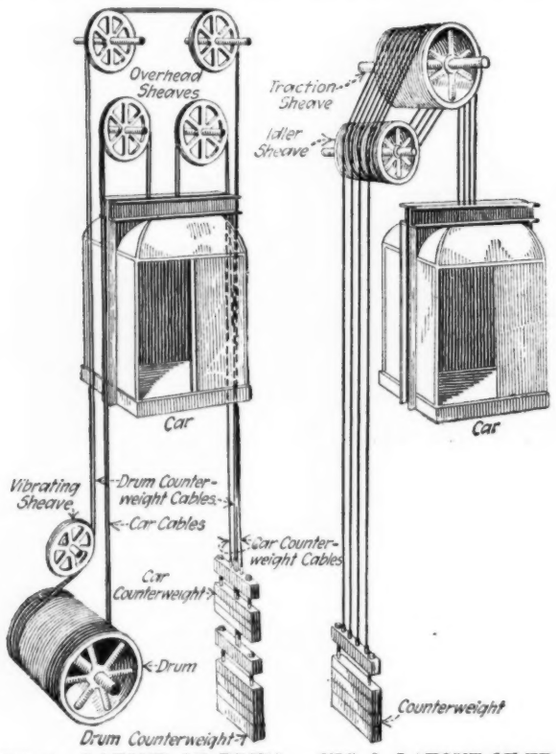


FIG. 1. LAYOUT OF DRUM-TYPE ELEVATOR

FIG. 2. LAYOUT OF TRACTION-TYPE ELEVATOR

A, Fig. 3, to which is bolted the winding drum or traction sheave as the case may be. The connecting medium between flange and spider is a "hub" *B* of varying length to meet the conditions of each installation. It is evident that the shorter the hub can be kept the more rigid and compact the machine. The hub is given a clearance fit where it passes through the gear case and is provided with an oil-throw groove or shoulder to prevent gear-oil leakage. Or, as is often the case, the hub may be machined down to become the journal of an extra bearing between the gear case and the drum. This flange and hub arrangement eliminates the use of keys for holding the gear and drum together, a very desirable feature considering the heavy stresses. The drum shaft passes through the hub and is keyed at the worm-wheel spider and at the outboard end of the drum. Since the worm wheel and drum are bolted together, the purpose of the keys is only to cause the shaft to revolve with the drum and gear wheel.

In case of some slow-speed, heavy-duty freight elevators the drum, instead of being directly connected to the worm wheel, is provided with an internal or external spur gear and is driven by a pinion on the worm-wheel shaft. This arrangement is not open

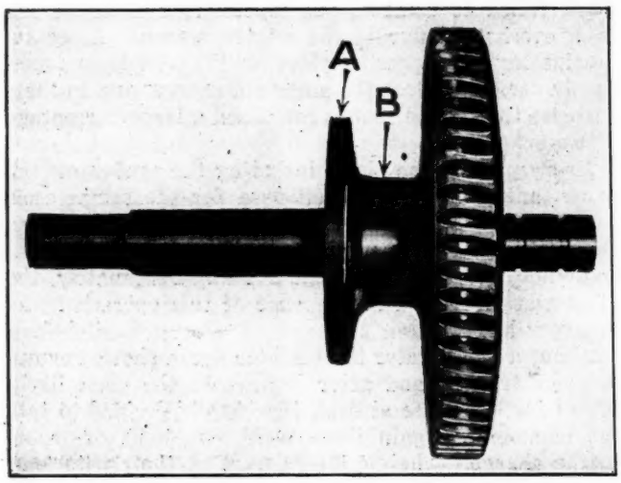


FIG. 3. ELEVATOR-MACHINE GEAR WHEEL AND DRUM SHAFT

to the objections that the straight spur-geared machine is, since the speeds of pinion and gear are extremely low. Fig. 4 shows an ordinary drum and Fig. 5 an internally geared drum.

Instead of depending on a single large cable, it is the rule to use a pair of smaller cables for both car and counterweights. To permit this, the drums are double spirally grooved, the second groove starting 180 deg. from the first and ending 180 deg. beyond the first. Sometimes two car cables and one drum-

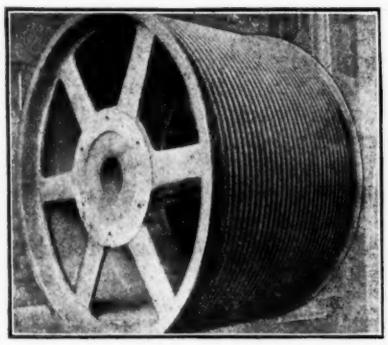


FIG. 4. ELEVATOR-MACHINE DRUM

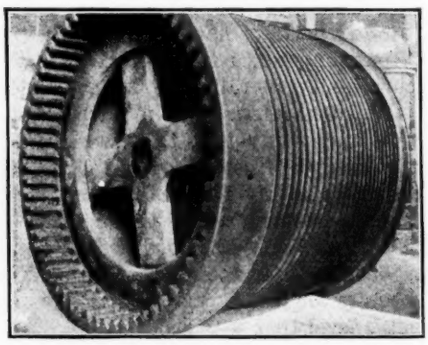


FIG. 5. INTERNAL-GEARED DRUM

counterweight cable may be found, or in other cases three car cables are used. In the latter event the drum must naturally be triple spirally grooved with

the grooves starting and finishing 120 deg. apart. In traction-type machines (Fig. 2) a multiplicity of cables may be used to obtain adequate traction. On the traction sheaves each groove closes on itself instead of using spiral grooving, since on the traction machine the cables unwind off the sheaves as fast as they are wound on.

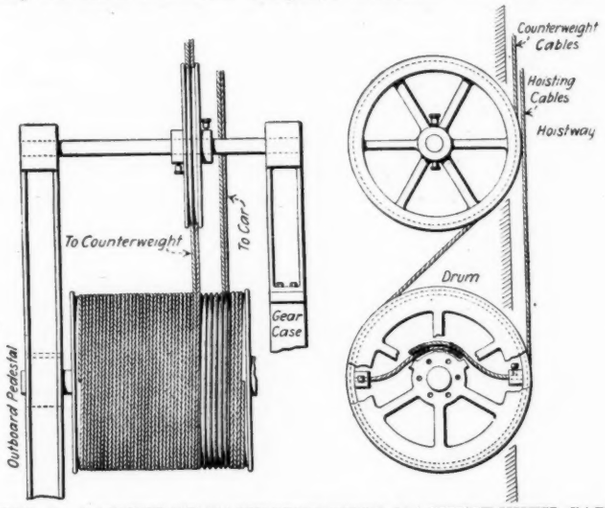


FIG. 6. LAYOUT OF BASEMENT-TYPE MACHINE WITH CAR CABLES RUNNING DIRECTLY FROM DRUM UP THE HOISTWAY

The layout of the machinery, hoistway and counterweights must be such as to give the cables the shortest possible paths, with the minimum number of sheaves and bends. The car (hoisting) cable must be particularly favored.

Figs. 6 and 7 show two typical layouts of basement machines. Fig. 6 is the better of the two, since the car cables have a straight path up the hoistway without an intermediate bend or sheave. The drum-counterweight cables necessarily leave the drum opposite the car cables and must be deflected to the hoistway by means of a grooved idler sheave. This sheave also takes care of the lateral motion of the cables as they wind on or unwind off the drum. The idler sheave must be allowed a lateral as well as a rotary motion, therefore it is frequently called a vibrator sheave. In modern practice this sheave is bored or bushed to give it a bearing fit on a fixed shaft. Oil or grease cups are provided in the hub, and the sheave is carried along by the cables themselves acting on the sides of the grooves. This is so simple and works out so well in practice that it is hardly worth while to make use of other means to give the vibrator a positive motion with the cables, such as threaded idler shafts, with the vibrator hubs acting as traveling units, shown in Fig. 8, and other similar schemes.

Fig. 8 is not in itself a positive means of avoiding strain on the cables against the side of the sheave, as unavoidable slippage of the cables in the grooves will obviously throw the sheave out of alignment with the cables. To overcome this fault the rim is provided with a number of projections *E* tapped for capbolts as at *A*. U-shaped stops *B* are provided on the pedestal or hangers so that when the car is run to either limit of travel and the sheave is off adjustment, one of the capbolt heads will strike its stop and the sheave will be stopped from further rotation. The cables must then slip in the grooves and the misalignment is corrected.

Vibrators are unnecessary in the overhead arrangement of basement-installed machines because of distance between machines and sheaves. For example, Fig. 9, if there is a lateral cable motion of 20 in. at the drum and the distance to a 24-in. overhead sheave centrally placed with regard to the 20-in. lateral travel is 100 ft., then the cable deflection at the horizontal diameter of the sheave will be 1/100 of 10 inches, or one-tenth of an inch, either side of the sheave center, which is easily taken care of by the sheave grooves without undue friction.

In Fig. 6 the vibrator shaft is supported on extension pedestals, one being bolted to the gear-case top, or cast integral with it, while the other is merely an extension of the outboard drum-bearing pedestal.

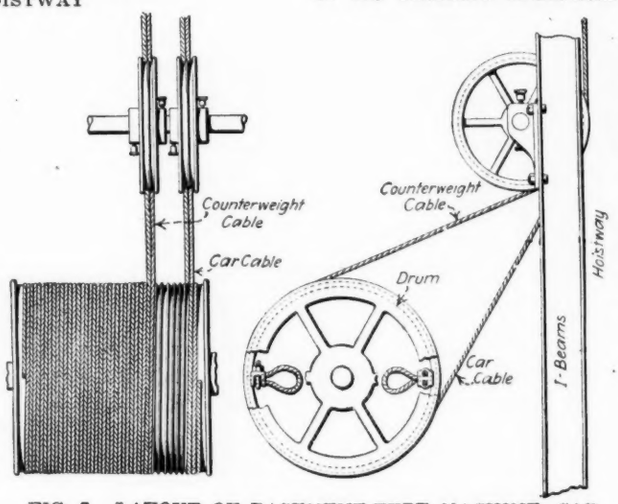


FIG. 7. LAYOUT OF BASEMENT-TYPE MACHINE, CAR CABLES DEFLECTED FROM DRUM UP HOISTWAY WITH SHEAVE

It is not always possible to place the machinery so as to bring the drum within the hoistway, in which case a second vibrator sheave, on the same shaft with the drum-counterweight cable vibrator, must be provided for the car cables. Where the offset of the drum in relation with the hoistway is not great, the desirable self-contained feature of Fig. 6 may be retained by the use of offset pedestal extensions as represented in Fig. 10. Where the distance is too great, however, the vibrator shaft must be separately mounted, as shown in Fig. 7, or on horizontal ceiling beams. The method of securing the cables to the drums is to insert the ends through holes provided at the begin-

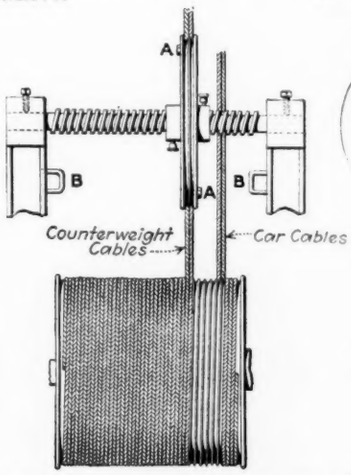


FIG. 8. VIBRATOR SHEAVE HAVING POSITIVE MOTION

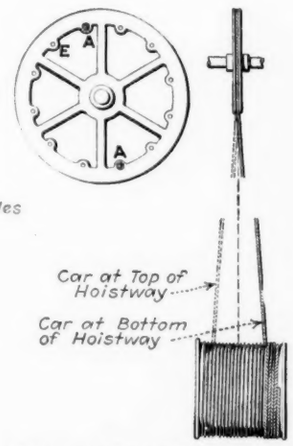


FIG. 9. INDICATES TRAVEL OF CABLES ON DRUM

nings and ends of the grooves and to bolt clamps to the cables within the drum. Fig. 6 shows a common method, using ordinary collars with setscrews. The ends of a pair of cables are then bound together with binding wire to prevent moving around as the drum turns. Fig. 7 represents another method, in which the cables are turned back on themselves and held by Crosby clamps; this is a convenient and reliable scheme, particularly where there is an odd number of cables. Another plan is given in Fig. 11, where each cable of a pair is

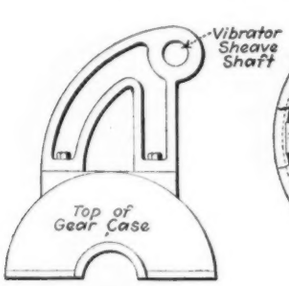


FIG. 10. OFFSET VIBRATOR-SHEAVE PEDESTAL

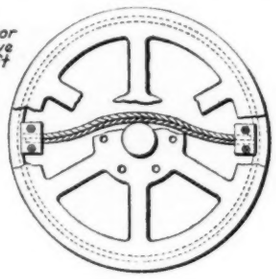


FIG. 11. CABLE CONNECTIONS INSIDE OF DRUM

carried to the opposite diameter of the drum and clamped with its mate, with flat or a Crosby clamp.

Fig. 12 shows a simple overhead arrangement of sheave and cables that could be used with Fig. 6 or Fig. 7, or any similar basement-installed machine. *A* and *A'* are the car-hoisting cable sheaves, *B* the drum-counterweight cable sheave, *B'* the car-counterweight sheave with two extra grooves to guide the drum-counterweight cables, and *B"* a combined drum- and car-

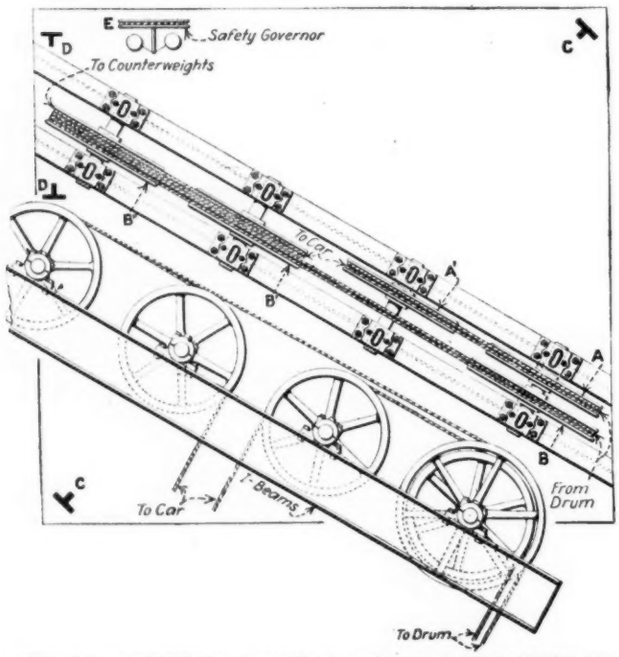


FIG. 12. OVERHEAD LAYOUT, SHEAVES ARRANGED IN STRAIGHT LINE

counterweight cable sheave. All are mounted on heavy I-beams set in the masonry of the housing. *A* is loose on its shaft and has oil or grease cups mounted on its hub. *B* is secured to its shaft and revolves with it. This is because the car cables and drum-counterweight cables necessarily move in opposite directions. *CC* are the car guide rails and *DD* the counterweight guide rails. *E* is the overspeed governor to be discussed in a later article.

Fig. 13 shows another of the very numerous overhead sheave arrangements in which *A* is the hoisting-cable sheave, *B* the drum-counterweight cable sheave, and *E* the car-counterweight cable sheave.

When the character of the building and hoisting permits, it is desirable to mount the machinery overhead instead of in the basement, since this permits the use of shorter cables, a smaller number of sheaves, etc.,

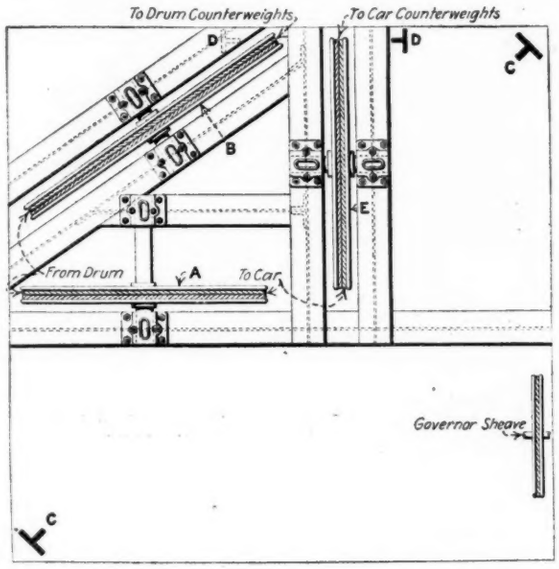


FIG. 13. OVERHEAD LAYOUT, SHEAVES ARRANGED IN A TRIANGLE

which are very desirable features. An overhead arrangement of the simplest and consequently the best type is shown in Fig. 15, where the hoisting cables and the drum-counterweight cables lead directly off the drum with no intermediary sheaves. This, however, can be done only when the drum diameter is equal to one-

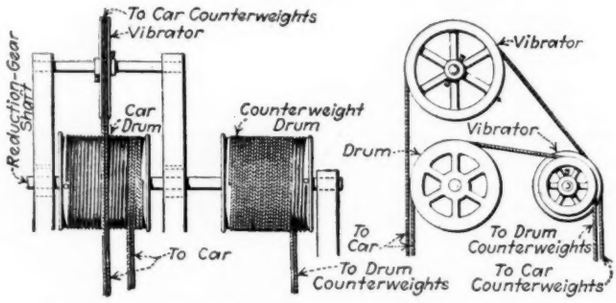


FIG. 14. ELEVATOR MACHINE WITH A CAR AND A COUNTERWEIGHT DRUM

half the width of the car. Fig. 15A shows a variation of the scheme, to permit the use of large cars. Here an additional vibrator sheave *A* is used to carry the counterweight cables over to where they will run down vertically to the counterweights. Fig. 14 is an unusual case where it was impracticable to provide sufficient counterweights in one pair of guide rails. Two drums were used, one for the hoisting and one for the counterweight cables, the illustration being self-explanatory.

In some of the figures where two vibrator sheaves are used they have been shown having different diameters;

however, this is only for clearness, since in all cases the two sheaves would be the same size.

Fig. 2 represents a typical traction-machine arrangement, the traction sheave being the one that is driven. Where the car is wider than twice the diameter of the traction sheave, the idler sheaves also act as a counterweight cable sheave. The cables leave the car, run over the traction sheave, around back to the traction and over the idler again and to the counterweights, thus obtaining the necessary frictional grip. The grooves of traction-machine sheaves must be full semicircular and must fit the cables. Also, all the grooves of a traction sheave must be identical in circumference, otherwise the cables in the longer grooves must slip to keep in step with those in the shorter grooves, with the resultant abnormal wear.

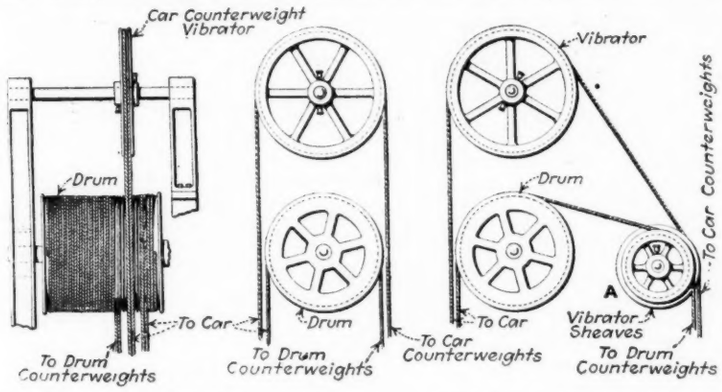


FIG. 15. OVERHEAD MACHINE, CAR DIAMETER LESS THAN TWICE THAT OF DRUM

FIG. 15A. OVERHEAD MACHINE, CAR DIAMETER OVER TWO TIMES THAT OF DRUM

Setting Valves of Busch-Sulzer Type A Diesel Engines

BY C. V. CLEGG

The type A Diesel is provided with a trammel or pointer on the side of the crankcase. This pointer, shown in Fig. 1, almost touches the flywheel and is used to check the crank positions in setting the valves. In practically all these engines the dead centers have been marked; if not, this is the first step to take. Some use a scale to measure the position of the piston. Another handy way is to lift out the admission valve and slip a nut on top of the piston. Turning the flywheel brings the piston up until the nut touches the cylinder head. This point is marked on the flywheel. The engine is then turned back until the piston again approaches the top on the back stroke. When the nut touches the cylinder head, mark this point on the flywheel. Bisecting the space between the two marks gives the top dead center. Since extreme accuracy is not needed at the bottom dead center, this point can be located by using a spirit level on the crank throw or web.

The opening and closing of the admission valves should next be checked. To detect the point at which the valves actually leave the seats, the engineer can twist the valve stem as the engine is turned over. As soon as the valve starts to open it will turn very easily; as soon as it closes it is impossible to turn the stem, owing to the friction of the valve on its seat. In Fig. 2 is given the usual timing, although many of the older engines had the admission valve closing at about fourteen degrees after dead center. Individual engines will vary slightly from this diagram.

If the admission and exhaust valves all show to be opening and closing too early or too late, it can be corrected by removing the intermediate gear on the camshaft drive and setting the whole camshaft forward or backward a few teeth, whichever the case may be. This can be done provided it is not too great a distance for the fuel-cam nose to be shifted; this is sometimes the case, for the fuel nose can be shifted back and forth only ½ inch at the most, this being the length of the slot made for the screws that hold the fuel nose to the cam body. In this instance, move the camshaft as far as the fuel nose will permit and place the intermediate gear back into position. Then proceed by shifting the admission and exhaust cam bodies off the keys. Start with No. 1 admission cam first, shift it along the shaft until the key can be removed. Then remove the key and shift the cam back into position and bar the flywheel over until you have the mark on the flywheel at the proper opening of the admission valve at the pointer. Turn the cam body around the shaft until the admission valve just begins to open, take a measure of the keyway, and make an offset key to fit. Proceed this way for all the admission and exhaust valves, with the opening point of all the valves properly set. Their closing position will not be far from correct.

The next step is to secure the proper setting of the fuel nose. Secure a fuel-valve roller from the storeroom, preferably a new one, also get a new fuel-cam nose.

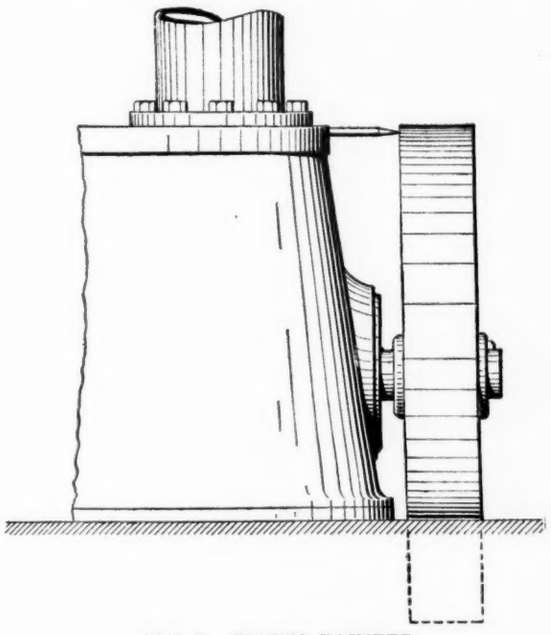


FIG. 1. TIMING POINTER

Place the roller on a sheet of good heavy paper and draw a pencil mark all around it, mark a center line through the circle drawn, extending it about twelve inches below, take the fuel nose and place the center line which is cut on the side of the nose, on the center line drawn through the circle about one-half inch below the circle, then draw an outline of the nose, as shown in Fig. 3. Take a sharp knife and cut the drawing out as sketched below, take the paper pattern, get some 12-gage iron and file out a

templet according to pattern, marking the center line on the templet.

Bar the flywheel over until No. 1 piston is on the top center with both the exhaust and the admission valve closed; be sure the lost motion in the gear is taken care of. Next loosen up the fuel nose that is on the cam body. Remove the shims and wedge and raise the fuel-valve lever high enough with a bar to put the templet you have made on the top of the fuel nose under the cam roller. Let the fuel arm back into position on the templet and shift the nose to its right place, as shown in Fig. 3.

It may be found that the nose will have to be ground off at the front edge or the wedge filed smaller at the back end to let the nose come to its correct position. When the nose is in the right place, the center line on the templet will line up with the center line on the nose and the roller will fit perfectly in the semicircle on the templet. After it is in the right position, make and fit shims to keep the nose from shifting back and forth and screw the bolts down very tight. Bar the flywheel backward off the top center fifteen or twenty inches so that all backlash will be out of the gears when the wheel is barred forward for the proper opening of the fuel nose, which is six degrees before top center. Now bar the wheel forward until the proper point of opening is at

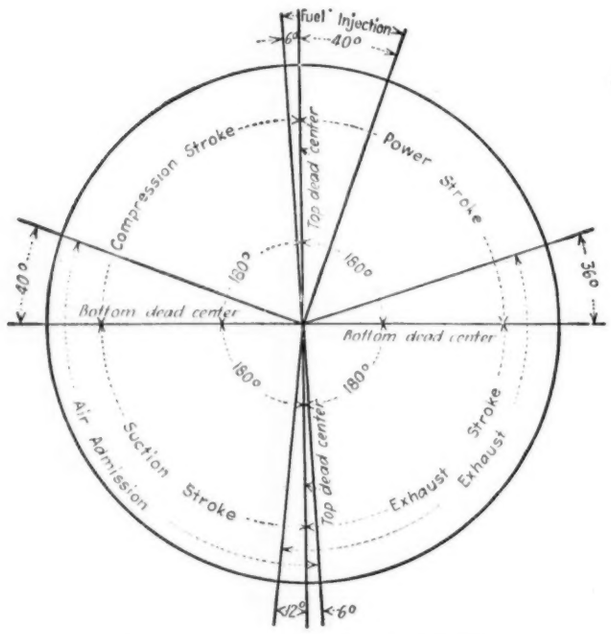
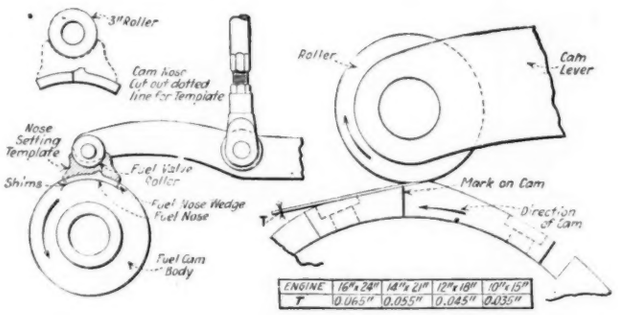


FIG. 2. TYPE "A" VALVE TIMING

the pointer, loosen up both the bottom and top nuts on the fuel-valve push rod, and place the fuel-oil bypass valves in the running position. Raise the admission valve push rod, and place the fuel-oil bypass valves in the running position. Raise the admission valve with easing gear, and turn on the injection air, using no more than twenty atmospheres of air. Then adjust the push rods so that one can just hear the air blow; while doing the adjusting, the bell crank on the fuel bracket should be tapped lightly with a hammer to keep it working freely. After the fuel valve is set on No. 1 cylinder, the other two fuel needles should be set the same way.

There are two types of fuel-cam noses used on type A engines. The one that the templet can be made for is the latest type and should be used with new style one-piece atomizers and flat-orifice nozzle. The other is the straight-side or tangent fuel-cam nose, and you cannot correctly use the templet for this style. To adjust the fuel-cam nose on gears, proceed as follows: The piston is first placed on top dead center on the power stroke. A gage of thickness given in Fig. 4 should fit the roller and the nose at the line marked on the nose if the setting is correct. If necessary, the nose can be moved by filing off one wedge and shimming the other until the



FIGS. 3 AND 4. METHODS OF ADJUSTING FUEL NOSES

nose is in the exact location, and the point of opening set as previously described.

After this type of engine has been in service for quite a while without the fuel-valve arm forks being renewed, the threads in the forks wear considerably and it is very important to watch out for this. It is a very convenient thing, but bad judgment, to leave the jam nuts on the lower ends of the fuel rods loose in the crank, as the quick opening and closing of the fuel valve often jars the upper jam nut loose, allowing the push rod to turn.

Should any of the gears break, the valve timing would practically be lost. When this templet is used, it is a very easy matter to set the camshaft back in its right place by barring the flywheel over until No. 2 piston is on top center, and then turning the camshaft in the position that the No. 2 fuel nose will have its center line at the proper place on roller or as near as possible. Then the fuel-valve arm can be raised and the templet placed on the nose.

The cam shaft can be moved back or forth, as the case may be, to make the center line on the templet line up with the center line on the nose. Placing intermediate gear in its position will cause all the valve settings to be the same as they were before the gear broke. The reason for using No. 2 fuel valve cam for this purpose is that No. 1 crank will be in correct position for the replacing of the intermediate gear.

The November issue of *Archivfur Warmewirtschaft*, otherwise *Heat Economy*, is at hand and appears to be a useful publication for students and others engaged in engineering research work. It is largely a review of current literature of which a majority, though not by any means all, is German. In fact, *Power* and other McGraw-Hill papers are mentioned quite frequently. Each reference gives a brief synopsis of an article and being printed on only one side of the paper, may conveniently be pasted on a card for filing. This issue of the magazine, which is a monthly, contains about eighty references and some general articles.

Armour System of Power-Plant Accounting—III

By O. A. ANDERSON
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For the production of electric light and power and of compressed air, the output is first determined, the charges tabulated and the unit cost developed. Motive-power report sheets for each service are given and typical examples are followed through in each case.

NOT giving sufficient consideration to the fact that electric power in the packing plant is a byproduct of the power house has frequently led some outside engineers to believe that the company has not kept pace with the times, as it is contended that central stations generate electric current on a more productive and economical basis. If the packing houses did not have use for large quantities of exhaust steam for heating buildings, they could not afford to compete. In the most recent installations of electric generating units a combined low-pressure induction and high-pressure bleeder extraction turbo-generating unit has been used for the purpose of balancing the exhaust-steam load. This makes a flexible and economical arrangement. In some of the plants where an abundance of exhaust steam has been available, low-pressure turbines have been used to good advantage.

Data Gathering and Accounting Methods

Accounting methods and the data gathered for electric service are given in Table I. Upon referring to this table, it will be noticed that under division 1, items (a), (e), (f) and (i) describe the generating unit, the data being obtained from the records of the machinery. The other items under this division are obtained from the power-house daily record or are the product of daily-record data and the hours during which the machines are in operation. The basic data are obtained for the purpose of determining subsequently the percentage of full load carried on the engines and generators.

TABLE I. MOTIVE POWER REPORT—ELECTRIC POWER AND LIGHT

1. Data on operation of power and light units:		
(a) Number of machine	1	
(b) Power or light unit		
(c) Total No. hours run	496	
(d) Speed, r.p.m.	85	
(e) Rated kw. of generatur	600	
(f) Rated hp. of engine	923	
(g) Total rated kw.-hr.	297,600	
(h) Total rated engine hp.-hr.	457,868	
(i) Type of engine	Corliss	
(j) Avg. inches vacuum	24	
2. Electric output and steam consumption:		
(a) Total kw.-hr. produced—power		
(b) Total kw.-hr produced—light		
(c) Total kw.-hr. produced—total	211,500	
(d) Avg. per cent load on gen.	71	
(e) Per cent mech. and elec. eff.	78	
(f) I.hp. per kw	1.72	
(g) Total i.hp.-hr.	353,780	
(h) Avg. per cent load on engine	83	
(i) Basis boiler hp. per i.hp.	0.41	
(j) Factor to correct for avg. load	1.08	
(k) Factor to correct for avg. vacuum	1.09	
(l) Actual boiler hp. per i.hp.	0.482	
(m) Boiler hp. per kw	0.83	
(n) Total boiler hp.-hr.	175,545	
(o) Exhaust steam to	Condens'r	
(p) Boiler hp.-hr. consumed (if total exhaust is used)		

*The first and second articles appeared in the Jan. 25 and Feb. 1 issues, respectively.

TABLE I. MOTIVE POWER REPORT (Continued)

Cost of Generating Electric Energy

3. Total cost steam to drive generating units ..... $———
4. Cost of labor to operate generating units:
(a) Portion of engineers' wages, per cent ..... $———
(b) Oilers ..... $———
(c) Switchboard men ..... $———
(d) Janitor service, per cent ..... $———
(e) Testing and indicating ..... $———
(f) Reports ..... $———
(g) ..... $———
(h) ..... $———
(i) ..... $———
(j) Total cost labor ..... $———
5. Cost of Supplies
(a) Lubricants—
.....Gal. of ..... @ $ ..... per gal. ..... $———
.....Gal. of ..... @ $ ..... per gal. ..... $———
.....Gal. of ..... @ $ ..... per gal. ..... $———
.....Lb. of ..... @ $ ..... per lb. ..... $———
.....Lb. of ..... @ $ ..... per lb. ..... $———
(b) Waste ..... $———
(c) Packing ..... $———
(d) ..... $———
(e) ..... $———
(f) ..... $———
(g) Total cost supplies ..... $———
6. Cost of repairs:
(a) General overhauling of engines ..... $———
(b) Minor repairs to engines ..... $———
(c) Repairs to generators ..... $———
(d) Oiling system ..... $———
(e) Exhaust line to exhaust header ..... $———
(f) Steam lines to header ..... $———
(g) Repairs to switchboard ..... $———
(h) ..... $———
(i) ..... $———
(j) ..... $———
(k) Total cost repairs ..... $———
7. Power and light portion of engine room lighting:
————kw.-hr. @ $———— per kw.-hr. ..... $———
8. Power and light portion of total steam condensing cost ..... $———
9. Total cost of generating units, switchboard and connections ..... $———
(b) Annual rental charge, 6 per cent ..... $———
(c) Annual depreciation charge, 5 per cent ..... $———
(d) Rental charge for period ..... $———
(e) Depreciation charge for period ..... $———
10. ..... $———
11. ..... $———
12. (a) Total cost generating electric power and light ..... $———
(b) Total cost generation per kw.-hr ..... $———

Cost of Power and Light Distribution

13. Cost of repairs:
(a) Distributing lines ..... $———
(b) ..... $———
(c) ..... $———
(d) ..... $———
(e) Total cost of repairs ..... $———
14. Cost of labor ..... $———
(a) Motor tenders ..... $———
(b) Lamp trimmers ..... $———
(c) ..... $———
(d) ..... $———
(e) Total cost labor ..... $———
15. Cost of supplies:
(a) Brushes, sandpaper, lubricants, etc ..... $———
(b) ..... $———
(c) ..... $———
(d) Total cost supplies ..... $———
16. (a) Total cost of distribution equipment ..... $———
(b) Annual rental charge, 6 per cent ..... $———
(c) Annual depreciation charge, 5 per cent ..... $———
(d) Rental charge for period ..... $———
(e) Depreciation charge for period ..... $———
17. ..... $———
18. ..... $———
19. (a) Total cost distributing electric energy ..... $———
(b) Cost distributing per kw.-hr ..... $———
20. (a) Total cost generation and distribution ..... $———
(b) Total cost per kw.-hr ..... $———

Total kilowatt-hours produced for power and lighting purposes is usually obtained by recording the difference in readings of the totalizing meters on each generator. If such meters should not be installed, the calculated kilowatt-hours determined for each twenty-four hours may be totaled and the result filled in opposite items (a), (b) and (c) of division 2. Dividing the total kilowatt-hours generated, as given in item 2(c), by the rated kilowatt-hours under item 1(g) will give the percentage of load on the generator. This value is par-

ticularly necessary in estimating the combined mechanical and electrical efficiency of the unit and is obtained from the curve shown in Fig. 1, which was developed from data received from a number of manufacturers of generating equipment.

Item 2(f) in Table I is the familiar 1.34 hp. per kilowatt divided by the electrical and mechanical efficiency. It represents the indicated horsepower of the prime mover required to develop a kilowatt-hour. The product of this unit and the kilowatt-hours produced by the generator will give the total indicated horsepower-hours required for the electrical load.

Determining Correction Factor

Previous to applying the steam rate to the engine horsepower-hours, the percentage of load on the engine is calculated and the correction factor determined from Fig. 1, so that the normal steam rate for the given type of engine may be properly corrected. It will be noticed that a correction factor is also applied for any variation in vacuum. It is readily obtained from Fig. 2.

After the correction factors for percentage load on the engine and for vacuum carried have been determined, the basic steam rate in terms of boiler horsepower per indicated horsepower, shown in item 2(i), is multiplied by the product of these two correction factors and a final corrected steam rate determined for item 2 (l). It is now apparent, with a corrected value for the steam rate in item 2(l) and the indicated horsepower required per kilowatt in item 2(f), that the product of these two items will give the boiler horsepower per kilowatt-hour, and this value appears in item 2(m).

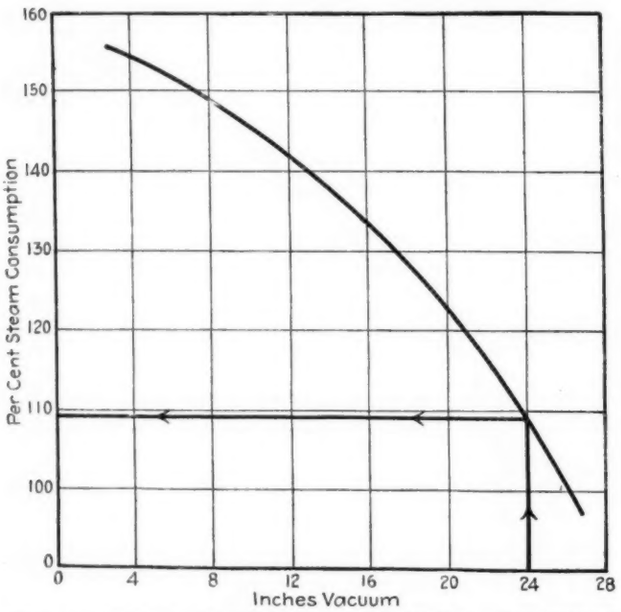


FIG. 1. CURVES TO CORRECT EFFICIENCY AND STEAM CONSUMPTION FOR LOADS OTHER THAN RATING

Subsequently, item 2(n) is calculated by multiplying the number of kilowatt-hours produced and the steam rate per kilowatt-hour. This value is charged in its entirety when the unit operates condensing, but when operating against a back pressure and the steam is used for process work or heating, only one-third of the steam is charged to the unit, the rest being chargeable to the operating departments using the exhaust steam.

Item 3 is the charge in dollars and cents for the steam actually used in all units generating electric power, the unit cost for steam being taken from item 24 in the motive-power report sheets presented in the first article of this series. It is the cost per boiler horsepower-hour or the cost to evaporate 34.5 lb. of water from and at 212 deg. F. The consecutive items 4, 5 and 6 are obtained from the master mechanic's record of labor costs, repairs

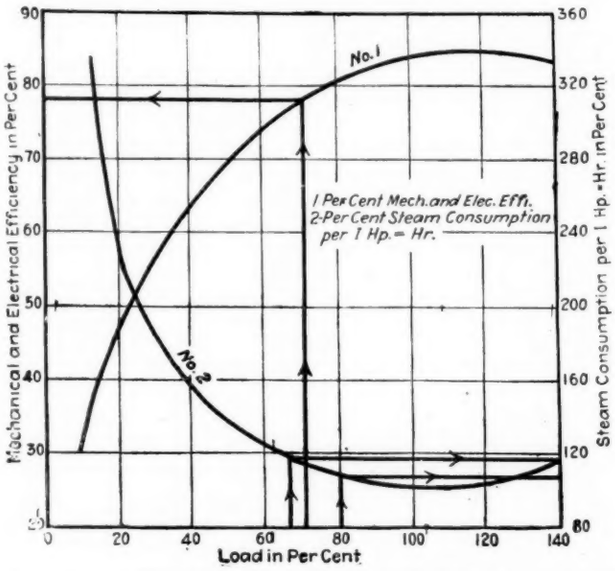


FIG. 2. VARIATION IN STEAM CONSUMPTION WITH VACUUM RATE AT 26-IN., VACUUM BEING 100 PER CENT

and supplies for the period in question. Proportionate charges are made for electric current in lighting the engine room. These costs are determined by the multiplication of the estimated kilowatt-hours used by the unit power cost for the previous period. Charge is also made for steam condenser operation.

Adding the rental and depreciation charges to the list of detailed operating costs gives the total cost for the generation of electric power and light. This value, however, contains only charges incurred in the power house. There are additional costs pertaining to distribution of power and light to the various departments of the factory. These are contained in items 13, 14, 15 and 16. It has been found convenient to charge all labor in maintaining the distribution lines to the motive-power department, the line of demarcation being the connections to motors and light circuit panels which belong to the department in which they are used.

The Calculations Involved for a Power Machine

As an illustration of the calculations involved for a power machine, take the case of a 600-kw. generator connected to a 900-hp. engine. The machine has been in operation 496 hours and the average speed is 85 r.p.m. The engine is a Corliss compound condensing unit operating on a vacuum of 24 in. The generator is equipped with a kilowatt-hour meter and the register shows that 211,500 kw.-hr. have been generated during the period. The total rated kilowatt-hours based on the capacity of the generator and the number of hours in operation is 297,600, so that the average load on the machine is 71 per cent.

Locating the 71 per cent load value on the abscissa of Fig. 2, reading up to the intersection with curve No. 1, and subsequently reading to the left, the ordinate value of 78 per cent will be the combined mechanical and electrical efficiency of the unit. This value, used in determining the actual indicated horsepower required per kilowatt, appears as item 2(e) in Table I. Item 2(f) is obtained by dividing 1.34 (equivalent horsepower per kilowatt) by 0.78. Item 2(g), the total indicated horsepower-hours, is obtained by multiplying the total kilowatt-hours generated—namely, 211,500—by 1.72, item 2(f), the product being 363,780. Dividing this last figure by the total rated horsepower-hours, determined by multiplying the rated horsepower of the engine by the number of hours in operation, gives item 2 (h), the average per cent of load on the engine or prime mover. In the case that has been cited this value is 80 per cent.

Referring to Table II, reproduced from the second article, showing the water rates for the various types of unit, it will be evident that the rate applied in this particular case will be 0.41 boiler horsepower per indicated horsepower.

Correction for Load Carried

To correct for the load actually carried on the engine other than that of rating, refer to Fig. 1. Reading up from the 80 per cent load value to curve No. 2 and reading horizontally to the right, it will be noticed that the correction factor is 1.08. Inasmuch as the steam-consumption values for condensing engines are based on a 26-in. vacuum, a correction is necessary. Referring to Fig. 2, read vertically from 24 in. of vacuum on the abscissa to the intersection with the curve and project horizontally to the left to get the correction value 1.09. The value 2(l) is now obtained by the multiplication of items 2(i), 2(j) and 2(k). The result is 0.482 boiler horsepower per indicated horsepower. Item 2(m), representing the actual steam consumption per kilowatt-hour, is the product of items 2(f) and 2(l), the result being 0.83 boiler horsepower per kilowatt-hour. The total steam consumption shown in item 2 (n) is the product of items 2(c) and 2(m), or 175,545 boiler horsepower-hours.

Inasmuch as all this steam passes to the condenser, a charge is made for the entire quantity of steam used. The cost is inserted as item 3 of Table I and is obtained as previously explained. The method of filling in the labor, supply and repair expenses will be obvious and needs no comment.

The total unit cost of distribution and production represents the cost of electric current as it is charged to the departments. Comparative tabulations for a large number of plants reveals any neglect or extravagance in the maintenance of any particular generating system. In this respect interesting facts often develop. Rapid changes in fuel prices will appear automatically in the system of comparative reports which are developing and decision as to whether changes should be made in fuel or fuel-burning equipment.

Production of Compressed Air

Compressed air is used for a varied number of purposes in the packing plants. Air lines cover the entire plant with taps provided for cleaning out all motors. Large quantities of air are used in the various factory departments in connection with process work and at some plants for pumping water. The usual operating pressure is from 70 to 80 pounds.

In the motive-power report sheet, Table III, the same procedure is carried out as for the previous record sheets. The production is first determined, and subsequently the charges are tabulated and the unit cost developed. Items 1(a) and 1(b) are obtained from the machinery records, and items 1(c), 1(d), 1(e) and 1(f) are taken from the power-house daily record sheet. The rated horsepower of the engine is calculated on the basis of the cylinder dimensions and mean effective pressure at one-quarter cutoff in the same manner as described in the second article relating to ice machines. The succeeding values and description under division 1 are self-explanatory.

Item 2 (a) calls for the volumetric efficiency, which is determined from indicator diagrams taken from each air compressor at some time during the period covered by the report. There is always an effort to forward as good cards as possible for this purpose, and this means that there will be adjustment of valves and gear motion at least once during the period in question. All this has the tendency to give added protection and efficiency to the plant.

TABLE II. BOILER HORSEPOWER PER INDICATED HORSEPOWER

In determining the boiler horsepower per indicated horsepower the following values are used for a load of 100 per cent of the rating of the engine, and in case of condensing units, for a vacuum of 26 in.

TYPE OF ENGINE	Boiler, Hp
Corliss compound condensing	0.41
Meyer valve compound condensing	0.48
Plain slide or piston-value compound condensing	0.60
Four valve Corliss compound condensing	0.55
Compound slide valve non-condensing	0.98
Compound Corliss non-condensing	0.67
Simple slide valve non-condensing	1.30
Simple Meyer or adjustable valve, non-condensing	1.00
Simple Corliss non-condensing	0.80
Simple poppet non-condensing	0.76

The number of cubic feet of free air actually compressed will be the product of the volumetric efficiency, the cubic feet displaced per revolution and the number of revolutions made during the period, the result being given in item 2(d).

Work Performed in Compressing a Gas

The next item calls for cubic feet of free air compressed per indicated horsepower-hour. Table IV has been prepared from the thermodynamic formula relating to work performed in compressing a gas between two different pressures, the adiabatic constant for air being used. These values have subsequently been increased to the manufacturer's guarantee on daily performances. Dividing the total quantity of air compressed by the proper value in Table IV gives the indicated horsepower-hours required from the prime mover.

Basic values for steam rates and correction for the percentage of rated load and degree of vacuum carried are applied as per the readings for items 2(h), 2(i), 2(j), 2(k) and 2(l). These values are determined in the same manner as the steam rates for the refrigerating machines and the electric power units, so that no additional comments are necessary. Where electric-driven compressors are used, the indicated horsepower is converted to kilowatts by multiplying by the value 0.746 divided by the efficiency of the motor. Steam costs and power costs are obtained by the extension of the number of boiler horsepower-hours per kilowatt-hour and the respective unit cost as obtained from the steam or power sheets.

Take, as an example, an air compressor designed to handle 600 cu.ft. of free air per minute, operating against an average air pressure of 86.5 lb. As may be noticed from the values given under item 1, this machine

TABLE III. MOTIVE POWER REPORT—COMPRESSED AIR

1. Data on operation of compressors:		
(a) Number of machine	1	
(b) Rated cu.ft. per minute	600	
(c) Average final air pressure	86.45	
(d) Total number revolutions made	3,747,853	
(e) Total number hours run	1,080	
(f) Average speed, r.p.m.	58	
(g) Rated hp. of engine	82	
(h) Total rated engine hp.-hr.	88,560	
(i) Type of engine	Comp. slide valve	
(j) Single or two-stage compressor	Two	
(k) Avg. inches vacuum	x	
2. Calculation of air compressed and power required:		
(a) Volumetric efficiency, per cent	90	
(b) Cu.ft. displaced per rev	6.51	
(c) Cu.ft. compressed per rev	5.85	
(d) Total cu.ft. air compressed	21,962,500	
(e) Cu.ft. free air comp'd per i.hp.-hr	373	
(f) Total i.hp.-hr	58,900	
(g) Avg. per cent load on engine	66	
(h) Basis b.hp. per i.hp.	0.98	
(i) Factor to correct for avg. load	1.18	
(j) Factor to correct for avg. vacuum	x	
(k) Corrected b.hp. per i.hp.	1.16	
(l) Total b.hp.-hr.	68,400	
(m) Exhaust steam to	Heater	
(n) B.hp.-hr. consumed (½ total if exhaust is used)	22,800	
(o) Kw. per i.hp.		
(p) Total kw.-hr. to drive compressors		
3. Cost steam to drive compressors		$
4. Cost electric power to drive compressors		$
5. Cost of labor to operate compressors:		
(a) Portion of engineers' wages ——— per cent		$
(b) Oilers		$
(c) Janitor service ——— per cent		$
(d) Testing and indicating		$
(e) Reports		$
(f)		$
(g)		$
(h)		$
(i) Total cost labor		$
Cost of supplies:		
(a) Lubricants—		
——— Gal. of ... @ $ ——— per gal		$
——— Gal. of ... @ $ ——— per gal		$
——— Gal. of ... @ $ ——— per gal		$
——— Gal. of ... @ $ ——— per gal		$
——— Lb. of ... @ $ ——— per lb		$
——— Lb. of ... @ $ ——— per lb		$
(b) Waste		$
(c) Air packing		$
(d) Steam packing		$
(e)		$
(f)		$
(g)		$
(h) Total cost supplies		$
7. Cost of repairs:		
(a) General overhauling of compressors		$
(b) Minor repairs to compressors		$
(c) Oiling system		$
(d) Exhaust lines to exhaust header		$
(e) Steam lines to header		$
(f) Main air lines		$
(g) Receivers		$
(h) Engine-room tools		$
(i)		$
(j)		$
(k)		$
(l) Total cost repairs		$
8. Air compressor portion of engine-room lighting:		
(a) No. kw.-hr		$
(b) Charge		$
9. Air compressor portion of total steam condensing cost		$
10. Water for intercoolers and compressor jackets		$
(a) Total M. gallons used		$
(b) Charge per M. gallons		$
(c) Total charge		$
11. (a) Total cost air compressors, complete with receivers and connections		$
(b) Annual rental charge, 5 per cent		$
(c) Annual depreciation, 5 per cent		$
(d) Rental charge for period		$
(e) Depreciation charge for period		$
(f) Insurance		$
(g) Taxes		$
12.		$
13.		$
14.		$
15. (a) Total cost compressed air		$
(b) Total cost per M. cu.ft. free air compressed		$

has been in operation about 1,000 hours, and has been operated at a speed of 58 r.p.m.

Indicator diagrams show that the volumetric, or clearance efficiency, is 90 per cent. Item 2(c) is obtained by the multiplication of items 2(a) and 2(b), and the total cubic feet of air compressed by the multiplication of items 2(c) and 1(d), the answer being 21,962,500.

Referring in Table IV to the column for two-stage compressors opposite a discharge pressure of 86.5 lb., it will be noticed that the cubic feet of free air compressed per indicated horsepower-hour is approximately 373. The total indicated horsepower-hours represented in value 2(f) is obtained by dividing 2(d) by 2(e), the result being in round figures 58,900. Dividing the value 2(f) by item 1(h) will give item 2(g), or the average percentage of load on the engine. It will be noticed in Table II that for a compound slide-valve non-condensing engine the steam rate will be 0.98 boiler horsepower per indicated horsepower. This value is filled in as item 2(h). In Fig. 1, reading up from the 66 per cent load value to the intersection with curve No. 2 and reading horizontally to the right gives 1.18 as the correction factor to be used for partial load, item 2(i). Inasmuch as this unit is operating non-condensing, there will be no correction to apply for the vacuum. Item 2(k) is now obtained by the multiplication of items 2(h) and 2(i), the product being 1.16. This value multiplied by item 2(f) gives the total horsepower, item 2(l), as 68,400.

It will be noticed that the exhaust steam goes to the heating system and therefore a charge is made only for one-third of the exhaust steam passing from the engine.

TABLE IV. AIR COMPRESSED PER INDICATED HORSEPOWER

Discharge Pressure Pounds Absolute	Cu.Ft Free Air Compressed per I.Hp.-Hr. Single-Stage	Two-Stage
35	765	..
45	568	...
55	465	...
65	402	405
75	358	405
85	326	373
95	302	350
105	282	329
115	265	310
125	252	295
135	...	286
145	...	276
155	...	265
165	...	257
175	...	251
185	...	244
195	...	239
205	...	232

The remainder of the steam is chargeable to the low-pressure steam consumer using it in heating or low-pressure steam process work. Therefore item 2(n) is obtained by taking one-third of item 2(l), or 22,800 boiler horsepower-hours. The charge for steam is obtained by multiplying item 2(n) by the unit cost of steam, as determined in the first article of the series. (See issue of Jan. 25.)

Costs of labor, supplies and repairs are taken from the maintenance book on these items. All expenses relating thereto are recorded from day to day in the master mechanic's office as the bills pass through. The air compressors are also charged for lighting, steam condensing, and water used in the intercoolers of two-stage machines. Inasmuch as the unit water cost has not been developed when the air sheet is made up, the unit cost of water for the previous period is used. In determining the total value chargeable to rent and depreciation, the basic initial value includes the cost of the compressors, receivers, connections and main headers to the respective buildings and departments.

All the air charges, including overhead, are totaled up and the unit cost per 1,000 cu.ft. of free air determined by dividing by the thousands of cubic feet of air compressed.

Efficient Handling of Fuel Oil—V

By ALLEN F. BREWER

IN PRACTICALLY every fuel-oil installation it will be necessary to use a pump to transmit the oil from the tanks to the burners. A certain amount of pressure will be required, dependent on the class of burners, grade of oil, number of burners in use and the quantity of oil to be burned. This pressure, in rare cases where gravity flow is possible under considerable head, may be directly obtained therefrom. Gravity feed to an oil burner, however, is not recommended; in fact in many places it is prohibited by ordinances. Hence an oil pump is a practical necessity in a modern oil-burning plant, so that a proper control of oil flow may be obtained whatever the conditions may demand. The purpose of the oil pumps, therefore, is to draw oil from storage and deliver it to the burners at the pressure desired and under constant control.

Three types of oil pumps are in general use: Steam-driven, simplex or duplex, piston or plunger type; belt-driven, triplex, plunger type; and electric-driven, triplex, plunger type. For general boiler-plant use the common steam pump of the duplex piston type will be found as economical and satisfactory as any, and the most easily repaired by the average labor.

Oil pumps should be installed in duplicate, operating but one at a time; then a breakdown will not cause the boilers to be shut down for lack of oil, and opportunity will be afforded for periodic cleaning and repair by simply switching from one pump to the other. The proper operation of an oil pump differs but slightly from that of a water pump; in fact, the chief difference is in regard to speed and output. In general it is considered good practice to run an oil pump at about half the rated speed for water, thereby cutting the rated delivery in gallons to about one-half. This practice places no excessive strain on the pump because of the heavier fluid, packing is not forced out and leakage past the piston or plunger is reduced to a minimum. In installing a pumping system it is well to remember this and select a pump of about double the rated speed and capacity as desired under maximum operating conditions.

On starting a pump the oil side may have become either air or gas bound, which will be indicated by racing of the pump at short stroke without pumping oil. To correct, open the air valve on top of the valve chamber until normal pumping occurs and oil flows freely, and then close the valve.

The matter of constant, steady pressure and uniform flow is most important for the successful burning of fuel oil. It is obtained only by a properly arranged pumping system and careful attendance. Unsteady pressure may cause vibration in the furnace, which arises from an unsteady flow of oil from the burner tip. In general, up to 250 lb. pressure, atomization of the oil will be increased as the pressure increases. This pressure is not recommended, however; never exceed 180 lb. is a safe rule. Pressure variation will arise most frequently from inequalities in the pumping strokes.

The equipment necessary to insure constant and steady pressure is either an air chamber or a relief valve on the pump itself, or a standpipe into which the oil is pumped prior to its flow to the burners. The latter is perhaps the simplest equipment, but with the disadvantage that it may not meet insurance regulations, as gravity flow is involved and there is a chance of flooding the furnaces if the burners accidentally go out or are thoughtlessly left turned on after the fires have been cut. Certain patented safety devices have been designed as a remedy, but they are not infallible and the only final remedy is careful attendance and being constantly on the job.

In principle the standpipe is simply a reservoir into which the pump delivers, the oil flowing by gravity therefrom to the burners. An overflow pipe is generally installed near the top, so that the oil is kept at a constant level, the excess flowing back to the suction line or storage tank. An added feature of the standpipe is that it serves as a final settling basin for water and sediment, these being drained from the bottom as often as necessary (see Fig. 2).

In using a standpipe keep the speed of the pump such that the delivery is somewhat higher than the consumption by the burners in order to keep the pipe filled and the pressure constant. In general govern the oil flow to suit the change in the load by varying the pressure or throttling at the burner valve. The required pressure is a matter of experience.

Most fuel-oil burning installations require the use of an oil pump to transmit the oil from the tanks to the burners. This article deals with the installation of oil pumps, how to insure a steady oil flow, the use and types of oil heaters and suction and discharge strainers The next article will explain the construction of oil-burning furnaces.

Air Chambers Insure Steady Oil Flow

As a means of insuring steady oil flow and uniform pressure air chambers should be installed on the discharge side of the pumps. In general they must be charged with air at a pressure of about 80 to 100 lb., dependent on the gravity of the oil pumped. Air chambers when properly charged will effectively remove all pulsations in the oil flow; they require frequent recharging, however, as the oil has a tendency to absorb oxygen from the air and thereby decrease the pressure. A pressure gage should always be fitted to an air chamber.

Should the air chambers become porous and not hold the air pressure satisfactorily, they should be tinned on the inside to remedy this trouble.

Relief valves installed on duplex oil pumps are another piece of equipment which will be of value in controlling the pressure, maintaining it as desired and allowing excess oil to flow back through a connecting pipe to the storage tank or suction line. Relief valves

should be fitted to the discharge sides of pumps and set to open when the desired pressure is obtained.

Valves, cylinders and pistons or plungers of oil pumps must be frequently and periodically examined and cleaned. The heavier the oil the more chance will there be for choking with heavy residue, dirt, etc. Running kerosene through will be found the best rapid means of cleaning out this foreign matter.

The Use of Oil Heaters

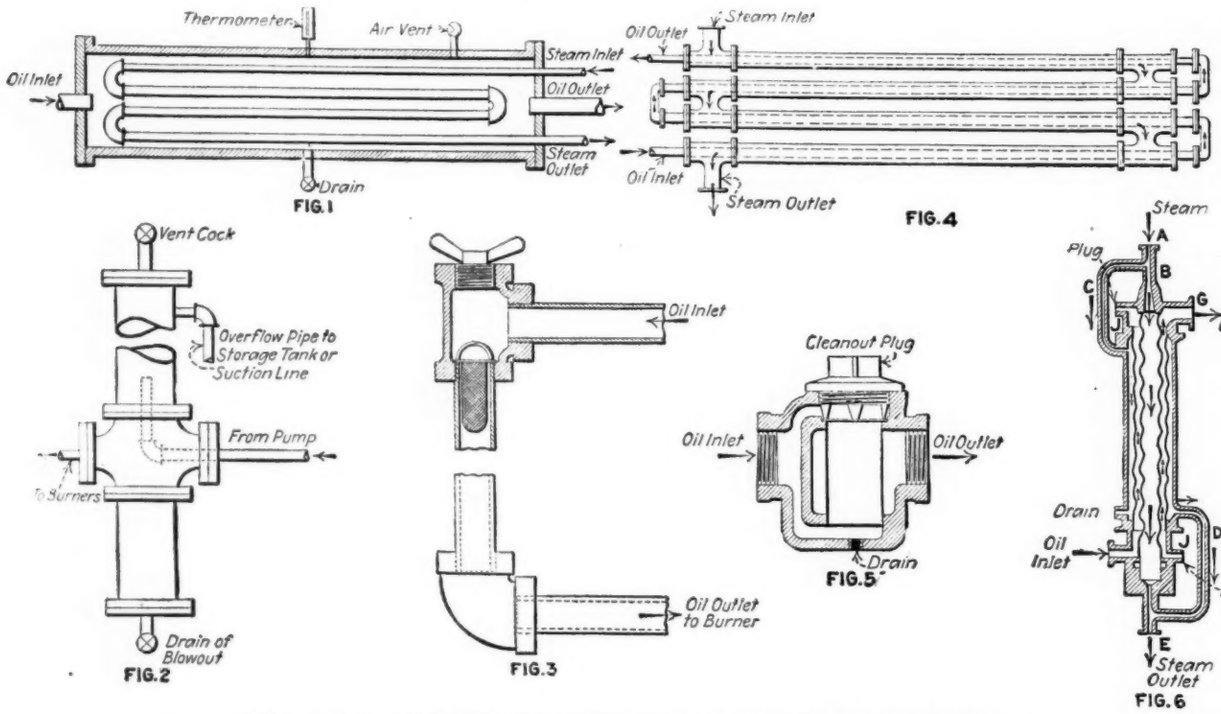
The purpose of an oil heater is to reduce the viscosity that an oil may possess, due to its natural condition or to cold weather, and make it sufficiently fluid for efficient, rapid flow and continuous atomization. The proper mixing of oil with air for combustion depends largely on the preheated temperature of the oil.

The temperature to which an oil must be heated to carry out the proper atomization will depend on the weight of the oil, and in cold weather on the degree of temperature in the suction line. The heating temperature should be just enough to raise the oil to the desired fluidity. There is a certain temperature for every oil, depending on its viscosity and gravity, where the viscosity is so reduced that a maximum amount of oil can be atomized. Above or below this temperature a reduction in delivery will occur. Too high a temperature will cause pulsation and unsteady burning. Too low a temperature will cause smoke and flaming in the uptakes; it may also cause injury to the brickwork. Trial and experience are the only definite guides in determining the proper temperature to heat the oil. The accompanying table will be found valuable as a general guide in most cases.

TABLE OF GRAVITIES AND CORRESPONDING PREHEATING TEMPERATURES

Baumé Gravity	Temperature, Deg. F.
10—12	280—300
12—14	270—280
14—16	250—270
16—18	200—240
18—20	170—200
20—24	150—170
24—28	150—150
28—35	140—150

In general an oil should be heated nearly to its flash point to insure complete atomization. If the latter is incomplete particles of oil can be seen dropping to the furnace floor, to carbonize there and burn with a smoky flame. Never preheat above the flash point. In the first place it is a dangerous practice; in the second place it will cause carbonization in the burner and oil piping, clogging these and requiring frequent and thorough cleaning. It is true that the temperatures given in the table may be far above the flash points for certain oils of the corresponding gravities. Therefore the table should not be followed blindly; it is simply given as a general guide, and no steps should be taken to preheat an oil without knowing its flash point.



FIGS. 1 TO 6. SOME DETAILS OF HEATERS AND STRAINERS FOR FUEL OIL

Fig. 1—Straight-pipe coil oil heater, cast-iron shell. Fig. 2—Standpipe built of pipe and fittings. Fig. 3—Tee-fitting strainer. Fig. 4—Double-pipe coil oil heater. Fig. 5—Basket type oil strainer. Fig. 6—Corrugated, spiral film oil heater.

Types of Oil Heaters

The most common type of heater is of coil or straight (return) tubular construction within an outer shell. Either steam or oil may be passed through the pipe or coil (see Fig. 1).

The corrugated film type of heater, Fig. 6, is also commonly used in naval and marine practice. It is, however, a more expensive type.

The double-pipe coil, Fig. 4, such as found in refrigerating plants, is another type of heater that is being used more and more. Its efficiency is high owing to the counterflow of fluids within, which causes the most nearly perfect heat transfer. It is commonly built of a 2-in. pipe within a 3-in. pipe, oil passing in one direction through the 2-in. pipe, while steam is passed into the larger pipe in the other direction.

Either live or exhaust steam may be used for heating oil. Exhaust steam contains almost as much heat as live steam and will be found more economical and less liable to cause leaky joints and allow water of condensation to mix with the oil.

Owing to the fact that fuel oils contain sulphur, sometimes as high as 5 per cent, it is not considered the most economical practice to use copper or cast-iron coils. The chemical action that occurs will eventually eat away these metals, weakening the coil or pipe and causing leakage. Regardless of this fact, however, copper-coil heaters are frequently installed. The best economy is obtained by using wrought-steel coils, piping and shell (when oil is to come in contact with the shell).

Testing and Construction

Inasmuch as oil heaters are subject to full pump pressure they should be made up with joints to withstand properly such pressure without leaking. Manufactured heaters are generally sold on a guarantee to withstand at least 200 lb. pressure. A home-made heater, however, should be carefully assembled, and joints made up with shellac or a litharge-glycerin paste to prevent leakage of water or steam into the oil.

All piping or coils should be built capable of free expansion and contraction without springing leaks at the joints. Always install a thermometer on an oil heater so as to know positively the temperature of the oil within at any time.

In operating a heater where the oil is passed through the coils the drain valve should be cracked just enough to keep the heater shell free from water of condensation and still maintain the steam pressure in the heater at about the same as that in the main supply line. The steam temperature will thus be at its highest.

Govern the steam supply by the supply-line valve in order to give the required oil temperature. Never try to accomplish the control of the oil temperature by opening the drain valve too far or by closing it entirely.

Suction and Discharge Strainers

Suction strainers are used to remove the sediment in the fuel oil prior to its pumping. They are used chiefly as a protective measure for the pump chambers, etc. Discharge strainers are used to strain the oil before its delivery to the burners, removing all remaining dirt, grit or sediment, and shreds of pump packing, thus avoiding the danger of clogging the pipes and burner tips and reducing the wear on the burners themselves.

Burner strainers are useful as a final straining precaution and are fitted either in the burner casting itself or in the oil piping just before the burner and are most usually found in marine practice. A satisfactory strainer should possess the following requirements: Large straining area, preferably several times the cross-sectional area of the oil pipe; mesh not easily deformed; ease of removal of the strainer basket for cleaning, preferably without tools; no chance of formation of air pockets in the strainer proper; should, in no position, have any parts such as handle, etc., which might stop oil flow by improper placing.

In general there is but one type of strainer—a piece of wire netting, wire gauze or perforated metal, either flattened or formed into basket shape and held in place in a suitable receptable, from which it may be easily removed for cleaning. There are any number of strainers, and the fireman is likely to come in contact with any of them. Essentially, they embody the same basic idea, hence no attempt will be made to describe any in detail. Fig. 5 shows the principles involved, the flow of oil being as indicated.

Perhaps the simplest form of strainer is a blind wire-gauze gasket held between two flanges in the oil piping. Such a device is difficult to clean, tedious and imperfect. There is no means of telling definitely the extent to which it is clogged except by a lagging of oil flow and the pump pressure building up.

The size of the mesh should be at least one-half the diameter of the orifice of the burner when the latter is of the round-flame type. For flat-flame burners a general safe size of strainer opening is about forty-mesh. Wherever possible, strainers should be installed in duplicate. This may seem expensive, but the saving in time and avoiding the necessity of cutting off the oil flow will much more than repay the first expense thereby involved.

When Double Strainers Should Be Used

In using certain oil fuels that contain excessive sediment double strainers are of advantage, particularly on the suction side of the oil pump. When possible small strainers should be installed at the burners to finally remove any foreign matter that may have slipped through the main strainers. Certain mechanical types of burners are built with a strainer cell in the burner casting itself. On other types the T-fitting strainer may be used (see Fig. 3). The life of a burner will depend to a great extent on the effectiveness of the strainers, hence no point should be overlooked in making the latter as efficient as possible.

The indications of dirty strainers are lag in oil flow, excess of white smoke at the stack and abnormal rise in the pump pressure.

Cleaning strainers in general is necessary every 24 hours. The frequency, however, should depend entirely on experience, and no definite time limit should be set if the oil carries a high percentage of dirt or sediment. To clean any strainer basket or mesh remove it from the container, dip it in kerosene and blow the mesh through with a steam jet. When a steam blowout line is attached to a strainer, should the oil used be very dirty or the strainer hard to clean, it will be found well when blowing out to close the blowout valve a moment and then open quickly. The extra, sudden pressure will generally force the dirt out cleanly. A vacuum breaker on a suction strainer is a valuable piece of equipment in order to facilitate easy removal of the cover.

Coming Into His Own

The so-called "monkey-wrench" engineer has been the butt of almost as many jokes as the much-abused mother-in-law. The following Want advertisement in a recent issue of a New York newspaper is an indication, however, that he is appreciated, at least once in a while. Here it is:

Monkey Wrench Engineer

First-class stationary engineer for large plant in New Jersey. Salary to start, $200 per month. License, experience, personality and potential ability must be of the best. Write completely, but briefly.

ADDRESS WESTING,
810 Broad St., Newark, N. J.

Motor Records in Industrial Plants

Reasons for Maintaining Records of Motor Operation—Information That May Be Obtained from Such Records—Uses to Which These Records May Be Put—A Complete Set of Record Cards Is Given and the Method of Using Them Described—How Data Are Obtained for the Record System

BY PHILIP CHAPIN JONES
Electrical Engineer, Goodyear Tire and Rubber Company of California

MOTOR records, when existing as a well-planned and maintained system, are invaluable to the industrial plant. Their worth is of so wide a range that to get the most from them they should generally be used by more than one department. To the accounting and cost departments they are of value as giving a reliable and up-to-date inventory of motor equipment and for insurance purposes. In fact, so important is this function of motor records that most large industries maintain such records for the cost department alone, whether the engineering department does so or not.

It is, however, from the engineering viewpoint that they will be considered here. They yield, primarily, data as to the distribution of the connected load. This information, used in conjunction with load data of various feeders, gives information that is indispensable for economically laying out feeders. In large factories both the load density (connected horsepower per square foot of floor area) and utilization factor (average kilowatts per connected horsepower) vary for different departments. To network the whole plant with feeders heavy enough to supply load densities equal to the greatest occurring in the plant requires an expenditure beyond all proportion to any advantage gained.

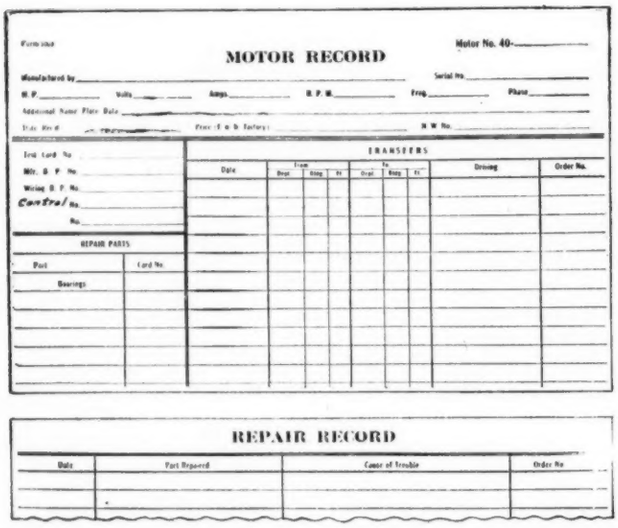


FIG. 1. MOTOR-RECORD CARD; FORM ON BACK OF CARD SHOWN AT BOTTOM

From an operating engineering viewpoint motor records are of value in giving data of individual motor performance. By means of such records it is possible to catch readly any recurring trouble and remedy it. Frequently, it will be found on an examination of motor records that certain motors are having too much bearing trouble or are burning out often. An investigation will follow which will always disclose some removable cause. One other use of motor records is in proportioning power costs to the different departments. It is almost always difficult to meter each department separately, not so much because of the cost of the metering equipment as because the departments do not lie in logical feeding groups, they overlap the natural feeder districts.

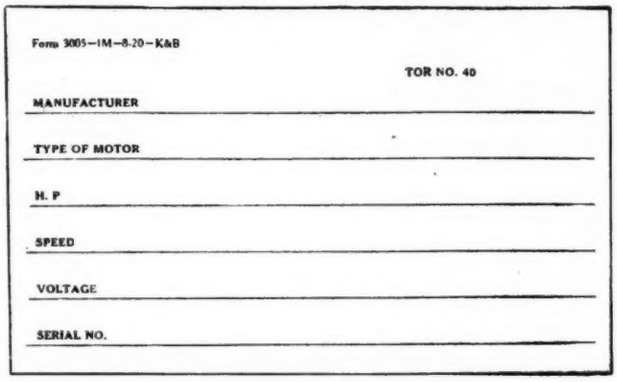


FIG. 2. INDEX CARD FOR FIG. 1

To make the feeders fit the departments will almost invariably mean large additional expense, without considering the additional disadvantage of the possible moving or enlarging of the department. From the records, however, it is possible to obtain the connected horsepower in any department, and this may be used with considerable justice in apportioning the power charges. A modification of this method by bringing in the factor of number of hours' use of a motor per month gives a very accurate apportionment of cost.

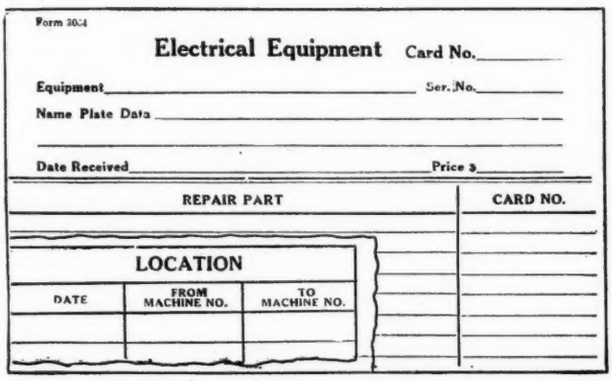
In order to obtain the maximum benefit from motor records, considerable attention must be given to the form of record used, which is, after all, the groundwork of the whole system. There are undoubtedly many possible schemes that are satisfactory. The one described here—devised by the writer for a plant having over 60,000 hp. of motors—has been used with complete satisfaction for several years.

As a basis of the system the motor-record card (5 x 8 in.) shown in Fig. 1 is used. Every motor is numbered with a factory serial number when it enters the plant. This is a composite number having a series number (40 in this case, which applies to all motors) and a serial number. This number is placed in the upper right-hand corner of the card for convenience in finding when going through the file. The manufacturer's serial number is placed immediately beneath it. The upper third of the card is given up to the complete name-plate data of the motor, date received and order number on which it was bought.

On the right-hand part of the lower two-thirds of the card is space for the location of the motor and the

machines driven. Recognition is given to the fact that during its life the motor will probably be moved about somewhat, and space is kept for ten moves, which is ordinarily sufficient. The last line filled in represents the present location of the motor. To the left are two small divisions—one for reference to other files such as blueprints (B. P.) of motors, test data, controls, etc., and the other for listing repair parts carried in stock that apply to the particular motor. For small alternating-current motors this generally is nothing but bearings, but for large motors or direct-current motors the list will be greater. On the back of the card is space for a record of all repairs to the motor. The methods of maintaining these cards up to date will be described later.

These motor-record cards are filed serially, but in order to obtain the various information desired indexes are needed. For this purpose the card shown in Fig. 2 is used. One or more of these cards are made out for each motor, depending on the number of indexes to be used. In the plant where these cards are used three indexes are kept: One according to motor manufacturer, one according to building and floor location of the motor, and one for department location of the motor.


Form 3014

Electrical Equipment Card No._____

Equipment_____ Ser. No._____

Name Plate Data _____

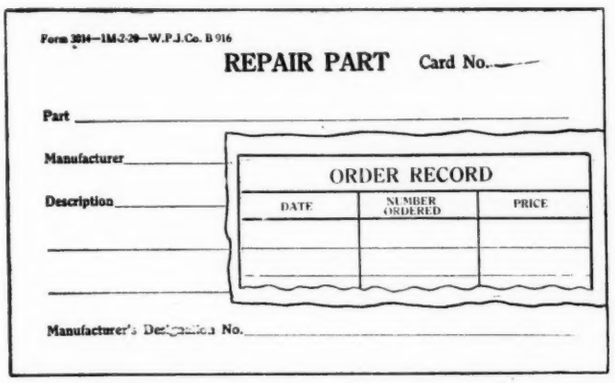
Date Received_____ Price \$_____

REPAIR PART	CARD NO.

LOCATION

DATE	FROM MACHINE NO.	TO MACHINE NO.

FIG. 3. ELECTRICAL-EQUIPMENT CARD; FORM ON BACK OF CARD SHOWN IN THE INSERT


Form 3014—1M-2-20—W.P.J.Co. B 916

REPAIR PART Card No._____

Part _____

Manufacturer_____

Description_____

ORDER RECORD

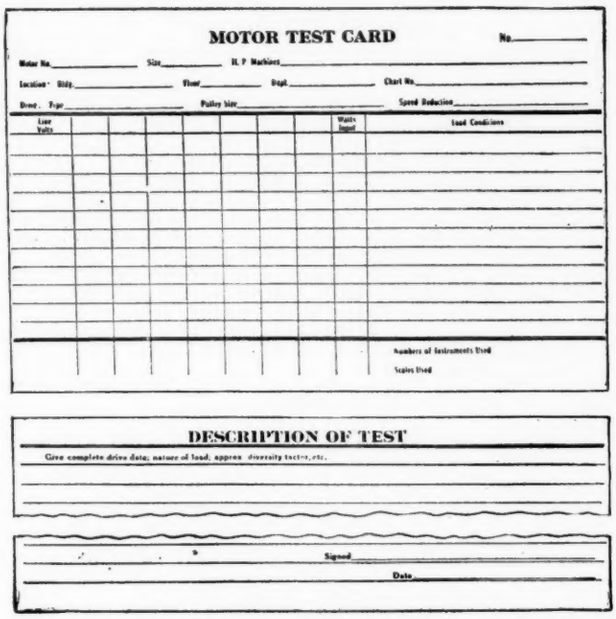
DATE	NUMBER ORDERED	PRICE

Manufacturer's Designation No._____

FIG. 4. REPAIR-PARTS CARD; FORM ON BACK OF CARD SHOWN IN THE INSERT

Sufficient data are put on these index cards to obviate reference back to the main card for any ordinary information required.

Figs. 3, 4 and 5 show auxiliary cards, which are numbered and filed serially and which are referred to on the main motor card. Fig. 3 is used for all motor-control equipment. This card, in addition to its serial number, on the upper half of the front has room for the controller name-plate data, and on the reverse side is space for a record of transfers, the last line giving the present location. For control equipment even more than for motors, it is necessary to keep track of the spare parts that are carried in stock, and the bottom part of the card is reserved for this purpose. It was originally intended to list the repair parts on each card, but as there are often a large number of pieces of equipment


MOTOR TEST CARD No._____

Motor No._____ Size_____ H. P. Machine_____

Location: Bldg._____ Floor_____ Dept._____ Chart No._____

Drive: Type_____ Pulley Size_____ Speed Reduction_____

Line Volts								Watts Input	Load Conditions

Numbers of Instruments Used

Scales Used

DESCRIPTION OF TEST

Give complete drive data; nature of load; approx. diversity factor, etc.

Signed_____

Date_____

FIG. 5. MOTOR-TEST CARD; FORM ON BACK OF CARD SHOWN AT BOTTOM

that are identical, such as compensators, it was found simpler to group together all control cards for like equipment and have a few cards in the front of each group giving the spare parts.

Fig. 4 shows the repair-part card. These are numbered serially from one up, and one is made out for each separate spare part carried in stock. This assigns a number to that part, which is its means of identification throughout the plant. This scheme greatly simplifies the stocking of spare parts. They are very difficult things to designate because they are small and so many are similar; therefore, unless they are properly designated and tagged, considerable confusion may follow.

Fig. 5 shows the motor-test card, one of which is filled out for every test that is made. These also are numbered and filed serially and are indexed by having the test-card number put on the motor card and also by a separate index listing the tests according to types of machines driven. Graphic meters are used to a considerable extent in making tests, and owing to their bulk the charts are filed separately. It will be noticed that a place is left on the test card for listing any chart numbers. Of the nine columns for test data all but two are left without headings, and the headings are filled in at the time the tests are made, to conform to the data taken. This was found to be the better way, as no one set of headings would serve for all tests. At the bottom of the card is left space for placing the numbers and scales of the instruments used, all meters being assigned serial numbers. This is valuable in enabling a check to be made any time after the test if there should be any apparent discrepancy in the data recorded. It also

makes it possible to make corrections if any meters are later found to be out of calibration.

The best-designed system of motor records in the world is valueless if it is not maintained. The weakness of most systems is in their maintenance, not their conception, and for this reason considerable attention must be given to this half of the question. The basis of the maintenance system is a daily motor report sent to the engineering department from the storeroom. This is merely a form-letter size sheet on which is listed every motor entering or leaving the storeroom. The data given include not only the factory serial number, but the manufacturer's name, size of motor, speed, order number on which it came in or went out and the location to which it is going. These reports are numbered serially and made out in duplicate, one copy being retained by the storeroom.

In smaller plants, where the passage of motors through the storeroom is not so frequent, instead of issuing a daily report it is better to send one up at the end of each day on which a motor passed through. With this system it is essential that the reports be numbered serially so that the engineering department can make sure it is not missing any reports.

Engineering Department Keeps Check on Reports

To serve as a check on the reports and as an additional source of original data, the man in the engineering department who handles these records has passed to him copies of all orders affecting motors. As practically all motors come into the plant on orders from the engineering department, and as no motor can be turned into the storeroom or taken out without an order which also passes through the department, this serves as a good check on the daily motor reports. As a secondary check on motors and also to keep track of controllers, the card shown in Fig. 6 is used. This is filled out by the electrical department every time a motor is connected or disconnected and sent to the record man.

This triple checking system is essential in large organizations. It is due not only to the fact that no

Form 3013, 1M- 2-20 W.P.J. Co. 35255

MOTOR INSTALLATION CARD. DEPT. 114

To_____ Dept Date_____

Installed in Dept_____ Bldg. No._____ Floor No._____ on Mach. No._____

Make	HP	RPM	AMP	Size	Type	Factory No.	Serial No.

Control

Make	HP	AMP	Size	Type	Fuse	Number	Kind

Order No._____

Foreman

FIG. 6. MOTOR-INSTALLATION CARD

one man can be depended on to be correct all the time, but to the large labor turnover which is constantly bringing inexperienced men into the office personnel. The importance of these various reports in the eyes of the storeroom keeper or the electrician is generally not very great, and the result is that the reports are likely to be put off, which, if allowed to continue, will become a habit. Therefore it is made a part of the record-man's duties to see that he gets all three checks and in reasonable time. The proper sequence is : Order, daily motor report, installation card. The data are kept on the copy of the order, and only after the installation card is received is the motor card permanently marked and the various indexes changed.

In keeping track of motor and control repairs a double check system is employed. There is first the copy of the repair order, which goes to the record man. Then, after the motor has been repaired, the electrical department turns in the card shown in Fig. 7. When these repair cards are received, they are checked against

Form 3015 1M 2-20 W.P.J. Co. 35254

MOTOR REPAIRS

Fact. No. 40:_____ Dept._____ Date_____ 19____

Make_____ H. P._____ Speed_____

Control Type_____

Character of Trouble_____

Character of Repairs_____

FIG. 7. MOTOR-REPAIRS CARD

the repair order and then entered on the motor card. On entering the repair, the record man glances up the card, and if there has been any similar trouble within the six months previous, he brings it to the attention of some member of the electrical-engineering department who handles that phase of the work, and the matter is looked into. By these means a great many bad conditions have been eliminated.

With a system of records such as outlined, it is a simple matter to take from it valuable statistics whenever they are needed. As a regular procedure the department index is taken out and run through on the adding machine to give the connected load in each department. This is used for power-charge determination. At less frequent intervals statistics are taken off to give the horsepower by buildings and floors, by manufacturers, by sizes of motors, etc. Studies are made of these for the determination of load density and diversity factor, and to keep track of the growth of the connected load, so as to plan for additional sources of energy before the need becomes acute.

A watch is also kept on the percentage of motors repaired per year. Each repair card, after the information has been transferred to the motor card, is filed according to the date of repair. This makes it simple to get the number of motors repaired during any interval of time, and a curve may be plotted showing the trend of percentage of repairs.

The cost of maintaining such a system is not great once the original card forms have been purchased. Even in the largest plants it will hardly require the entire time of one man, and as young men at moderate salaries may be used for this work if they are carefully chosen, the salary expense is not heavy, and the gains made from eliminating motor trouble alone will pay for the maintenance of the system. The record cards are made in two sizes; namely, Figs. 1 and 5, size 5 x 8 in. and Figs. 2, 3, 4, 6 and 7, size 3 x 5 inches.

Testing Steam Cylinder Oils

By W. F. OSBORNE

THE method to be adopted in testing a steam cylinder oil depends a great deal upon the object of the test. It is obvious that an operating engineer who makes tests of two or more oils to see which one is best suited to his conditions will not have to make as complete an examination as the lubrication engineer who is trying to find out whether the lubrication conditions can be improved.

Comparative tests are made to determine the relative efficiency of lubrication when using equal quantities of different oils or to find out the minimum quantity of each oil required for efficient lubrication on a particular unit.

In making such tests it is important that all operating conditions should be identical on each test and, when this is not possible, that enough data are taken to fully identify the influence of the variable factors.

The usual method of making such a test is to examine the cylinders and valves carefully before and after the test, to compare the efficiency of lubrication and to measure accurately the consumption during the test.

It is not always possible to secure all these readings on every installation, but the engineer should take as many of them as are applicable to the particular engine under test.

A. Data to Take Just Before Starting Test

1. Remove cylinder heads and examine cylinder.
2. Note condition of cylinder surface:
   a. Abrasions.
   b. Cuts.
   c. Rough spot.
   d. Character and color of polish.
3. Note condition of piston and piston rings:
   a. Sharp edges.
   b. Measure thickness of ring.
   c. Ring tension.
4. Clean valves and counterbore of any deposits.
5. Measure amount of oil in lubricator.

B. Readings to Take During Test (Hourly)

1. Time of starting, time of each reading and time of ending test.
2. Steam pressure at throttle
3. Steam temperature at throttle (shows presence of superheat).
4. Percentage of moisture in steam (high percentage requires more oil than a low percentage).
5. Steam pressure in receiver (compound engines); indicates temperature available for atomizing oil to low-pressure cylinder).
6. Exhaust pressure.
7. Revolutions per minute.
8. Load.
   a. Kilowatts if driving generator.
   b. Indicator card if driving machinery.
9. Drops of oil per minute to each feed.
10. Quantity of oil furnished to lubricator.
11. Character of piston rod leakage:
   a. Relative amount.
   b. Milky (indication of saponification).
   c. Clear (improper saponification or atomization).
   d. Liquid oil (improper atomization or too much oil).
12. Character of oil in condensation from exhaust (same as No. 10).
13. Character of water from receiver trap (same as Nos. 10 and 11).
14. Any unusual sound of groaning or sticking valves, indicating lack of lubrication?
15. Any slugs of water entering cylinders?

C. Data to Take at End of Test

1. Remove cylinder heads as soon as possible. The oil is likely to evaporate with the moisture due to the temperature and the observations of the oil film will not be accurate unless done quickly.
2. Determine thickness of oil film by absorption method. This test is made by pressing firmly against the cylinder wall several thicknesses of cigarette paper of a uniform thickness. The paper will absorb the oil and also pick up any foreign matter or deposits. Be careful to use a uniform pressure, not too heavy, and do not rub the paper on the cylinder wall.
3. Take impressions from top, bottom and each side at the center of the cylinder.
4. Note the number of thicknesses of paper saturated by the oil and the character of the stain.
5. Examine carefully cylinder walls and valves and note condition:
   a. Abrasions.
   b. Cuts.
   c. Rough spots.
   d. Dry spots.
   e. Color and character of polish.
   f. Oil pools.
   g. Gumming or deposits.
6. Examine piston and rings:
   a. Sharp edges.
   b. Measure thickness of ring.
7. Measure amount of oil remaining in lubricator.

D. Conclusions

1. Efficiency of lubrication:
   a. The number of thicknesses of cigarette paper saturated indicates the relative amount of oil on the cylinder walls; one or two thicknesses indicate sufficient lubrication (see C, 2, 3, and 4).
   b. A clear brown stain is O.K.
   c. A black stain may indicate carbonization of oil.
   d. Small black particles in the stain indicate worn metal from cylinder, piston or rings, or foreign matter coming in with the steam or from wearing of valves.
2. Condition of cylinder walls (see C 5):
   a. Any new abrasions or cuts may indicate lack of lubrication some time during the test, or may be caused by defective piston rings or foreign matter.
   b. Dry spots indicate faulty lubrication and their causes are many.
   c. A mirror-like polish is an indicator of good

lubrication and its color will vary with the oil, temperature conditions and the character of the metal.

d. Oil pools in the counterbore or valve pockets indicate excessive feed or improper atomization.

e. Gumming, carbon or other deposits should not occur, and their cause investigated.

3. Condition of piston and rings (see C 6): Amount of wear indicated by sharp edges and the thickness of the ring.

4. Efficiency of atomization observed while engine is running:

a. Piston rod leakage (see B 11): (1) Milky—indicates proper saponification, (2) clear—indicates no saponification or improper atomization, (3) liquid oil—indicates improper atomization or too much oil fed:

b. Oil in exhaust condensate (see B 2): Same as (a).

c. Water from receiver trap (see B 13): Same as (a).

5. Economy of lubrication.

a. Quantity per hour. Add amount supplied during test (B 10) to the initial filling of lubricator (A 5), subtract the amount in the lubricator at the end of the test (C 7) and divide by the number of hours (B 1).

b. Quantity per horsepower or kilowatts per hour: Divide the oil consumption per hour (D 5a) by the kilowatt (B 8a) or horsepower (B 8b).

6. Give due consideration to the effect of the differences on comparative tests shown by items B 2, 3, 4, 5, 6, 7, 14 and 15.

These data will give the lubricating economy of an oil used on a particular engine or the comparative value of several oils used on a single engine. When the lubrication engineer makes an investigation to determine the most suitable oil to use or to see whether changes in conditions might be made to improve lubrication he must give attention to a number of other features, particularly when he wishes to compare the lubricating performance of two different types of engines. The data listed below should, if possible, be secured, in addition to the data obtained on actual tests.

General Data to Be Obtained

1. Type of engine (for comparing economy of oil with other engines):

a. Horizontal or vertical. The weight of the piston of the horizontal cylinder increases the pressure on the cylinder walls, necessitating a thicker oil film and more oil than is required for the vertical cylinder.

b. With or without tail rod. Use of tail rod relieves weight of piston on cylinder wall and reduces oil consumption.

c. Unaflow or counterflow. Influences amount of condensation and cylinder temperature, which affects oil film, and amount of oil necessary to maintain it.

d. Simple or compound. Has an influence on cylinder temperature and water conditions which affect oil film. Compound engine usually requires additional oil fed to low-pressure cylinder to replace that lost in the receiver.

e. Condensing or non-condensing. Condensing engine has lower cylinder temperature, increased amount of moisture and requires more oil than non-condensing engine.

f. Kind of valves—slide, piston, Corliss or poppet. Poppet valves require practically no oil except for the valve gear. Piston valves are easier to lubricate than slide or Corliss.

2. Name of builder (for comparative purposes). The engines of some builders have certain characteristics which sometimes affect lubrication.

3. Size of cylinders.

4. Revolutions per minute.

5. Rated horsepower. (Items 3, 4, 5 are used for comparing oil consumption of different engines).

6. Type of piston rings (for comparative purposes). Some piston rings wear out the cylinder walls faster than other types and require more oil.

7. Character of load:

a. Variable or steady. A variable load presents a more difficult lubrication condition than a steady load.

b. Percentage of rated horsepower. Affects condensation, steam velocity, oil atomization and cylinder temperature.

8. Type and make of lubricator:

a. Mechanical.

b. Hydrostatic.

9. Location of point of introduction of oil:

a. On the valves.

b. Direct into the cylinder.

c. Into the steam chest.

d. Below the throttle.

e. Into the line above throttle.

Influences atomization of the oil, the efficiency of lubrication and oil consumption.

10. Character and source of boiler water:

a. Kind and amount of chemical compound present. Strong alkali or acid in the water has a bad effect on the oil film and requires larger quantities of oil.

b. Efficiency of boiler water treatment. This affects the amount of chemical compound and foreign matter carried into the cylinder. Efficient treatment reduces amount of oil required.

c. Foaming or priming. Any excess moisture added to the steam through priming works the oil off the cylinder walls and increases the amount required to give efficient lubrication.

11. Location and efficiency of steam separator:

a. An efficient separator reduces the amount of moisture reaching the cylinder and lowers the amount of lubricating oil required to give efficient lubrication.

b. The location sometimes limits the point at which the oil can be introduced.

With all this information the lubrication economy of one engine can be compared with that of another, and it will be found very frequently that by using an oil of slightly different characteristics the efficiency of lubrication can be much improved. The characteristics of steam cylinder oils and the effect on them of various operating conditions is covered in an article by the author on "Steam Cylinder Lubrication" which appeared in *Power* Jan. 27, 1920.

Central-Station Horsepower in the United States

In the table herewith is shown the total horsepower installed in the central stations in the United States. The stations are shown by states, while the prime movers are divided into the several types. The totals are of interest as showing the great preponderance of the steam turbine over the steam engine; the total horsepower of hydro-electric plants is large, but represents only a fraction of the possible development.

The horsepower of internal-combustion engines in central stations totals 191,874. In view of the past availability of natural gas the horsepower of natural-gas engines is not as large as might be expected. On the other hand, the horsepower of producer-gas engines is surprising, since there has been but little activity in the gas-producer field for several years.

Probably the item that calls for most comment is that of the horsepower of the "Carburetor" engine. In this class have been placed all internal-combustion engines using carburetors and burning gasoline, kerosene or distillate fuel. These engines are installed in small plants, and the engines are of low powers. They will use not less than one pound of fuel per horsepower-hour. On a ten-hour working day the loss of fuel from using these engines rather than the more efficient oil engines will probably amount to 3,000,000 gal. a year.

The semi-Diesel engines in central stations, amounting to 33,027 hp., are of sizes ranging from 200 down to 10 hp. The average will be around 75 hp. The total number of these engines will equal the number of Diesel engines in central-station use.

The Diesel engines total 80,870 hp. As might be expected, the greatest number are found in those Central States west of the Mississippi where the coal prices compare very unfavorably with the cost of fuel oil. The number of Diesel engines installed in the central stations is increasing each year. It is generally recognized that in small and medium-sized central stations the internal-combustion engine is the logical prime mover. Many of these stations now using less efficient units may be expected to turn to the oil engine.

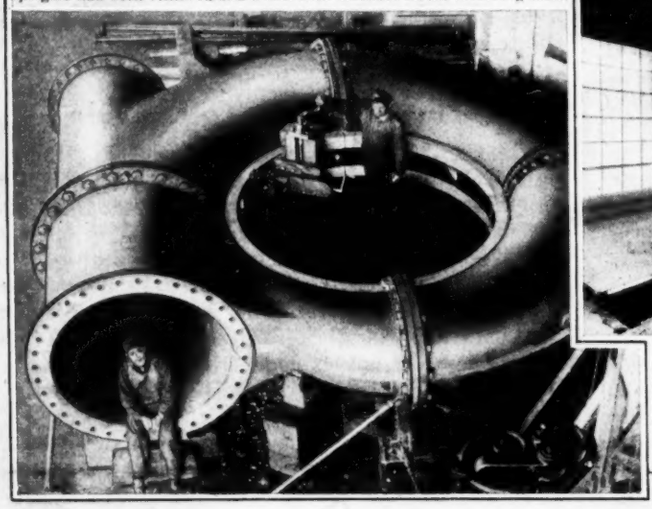
They Continue To Explode

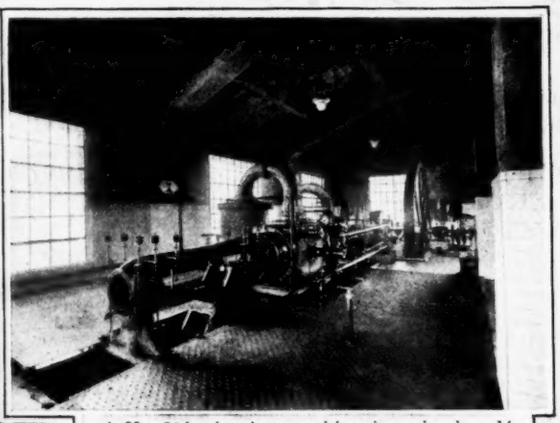
In *Power* for Jan. 11 it is stated that "there are those who insist upon making and using boilers that do not comply with the requirements of safety as defined by accepted authorities. The claim is made that for the service to which such boilers are put—oil country, lumbermen's contractors' and agricultural uses—the extra cost of the safer boiler is not warranted. . . . This condition will work itself out in time. If these cheap boilers do not explode from inherent faults, it will be apparent that they have been treated with unwarranted severity. If, however, the custom of the experts is justified, and boilers explode because of practices the danger of which has been publicly and repeatedly pointed out, any court will find their explosion to be due to gross negligence and the damages and opprobium will be found more onerous than the small additional cost of the safe standard boiler." Since this was written the explosion of two such boilers has been recorded in *Power*. We do not get them all. The very remoteness from centers of population that is urged as an excuse for their tolerance often keeps the news of such accidents out of the public prints. Information of any such failures that may become known to *Power* readers will be appreciated by the editor.

HORSEPOWER AND TYPE OF PRIME MOVERS IN CENTRAL STATIONS

State	Steam Turbine, Hp.	Steam-Engine, Hp.	Waterwheel, Hp.	Natural-Gas Eng., Hp.	Producer-Gas Eng., Hp.	Carburetor Eng., Hp.	Semi-Diesel, Hp.	Diesel, Hp.
New York	1,335,900	90,600	738,800	115	2,335	465	280	3,155
Pennsylvania	1,062,000	162,500	205,100	11,960	50	.....	.....	.....
Ohio	1,050,000	138,800	40,700	5,320	.....	105	85	2,140
Massachusetts	773,000	68,700	139,200	.....	300	40	.....	240
Illinois	712,300	161,400	114,000	.....	.....	.....	640	2,395
Michigan	427,500	44,200	216,500	.....	750	277	327	.....
California	403,700	32,300	810,300	.....	.....	.....	350	2,260
Missouri	392,900	59,700	27,300	.....	.....	1,029	2,144	2,375
New Jersey	351,600	74,700	1,300	.....	1,835	480	1,283	.....
Indiana	317,600	68,000	28,800	.....	.....	.....	70	1,375
Delaware, Maryland and Dist. of Columbia	280,000	34,700	15,300	170	400	75	.....	.....
Wisconsin	196,100	79,900	204,600	.....	775	1,785	502	1,640
West Virginia	196,000	16,300	3,500	19,285	.....	72	.....	.....
Rhode Island	183,800	6,000	2,700	.....	.....	.....	.....	.....
Texas	175,900	60,500	4,100	2,935	1,075	1,311	5,509	22,345
Connecticut	169,200	18,500	40,500	.....	.....	.....	.....	1,125
Virginia	158,200	13,100	49,900	.....	45	72	240	.....
Minnesota	139,200	34,000	157,700	.....	550	426	925	2,675
Iowa	124,000	65,700	160,400	.....	.....	.....	2,199	2,725
Kentucky	120,200	26,800	200	.....	.....	.....	475	590
Kansas	106,900	41,900	26,100	.....	.....	.....	5,055	6,205
Colorado	92,200	20,400	78,300	.....	.....	.....	160	180
Tennessee	91,600	16,400	98,000	.....	.....	155	170	100
Alabama	83,600	31,000	80,600	.....	.....	.....	.....	75
North Carolina	81,300	21,300	169,600	.....	100	100	50	.....
Georgia	80,300	41,600	223,430	.....	.....	.....	370	.....
Louisiana	73,000	37,400	35,200	.....	.....	.....	460	3,725
Nebraska	68,300	25,500	12,500	.....	.....	3,163	3,519	4,460
Washington	60,800	18,300	341,400	.....	.....	180	255	.....
Florida	53,400	22,900	7,000	.....	.....	.....	300	2,435
Oregon	47,500	18,900	132,000	.....	.....	152	100	.....
Oklahoma	43,500	44,200	1,800	5,900	65	561	1,825	6,175
Arkansas	42,400	26,600	2,200	.....	.....	.....	405	1,490
Mississippi	30,200	20,300	.....	.....	.....	125	1,085	.....
South Carolina	28,000	10,600	279,600	.....	3,000	.....	370	200
Arizona	26,100	9,900	39,000	.....	.....	.....	80	5,365
Utah	21,300	11,900	95,600	.....	.....	.....	.....	.....
New Hampshire	21,000	23,000	46,000	.....	.....	10	250	900
Maine	16,900	16,800	186,000	.....	.....	.....	50	.....
Wyoming	15,800	6,900	2,700	.....	.....	.....	462	1,000
South Dakota	14,600	7,900	7,000	.....	4,711	1,389	1,488	4,205
Vermont	12,600	7,800	106,500	.....	.....	.....	.....	.....
North Dakota	6,400	19,400	.....	50	1,025	1,395	960	.....
New Mexico	3,900	7,000	600	.....	1,300	415	170	930
Montana	2,500	11,600	303,400	.....	.....	240	327	780
Nevada	1,900	900	15,400	.....	.....	300	.....	.....
Idaho	.....	4,500	126,600	.....	.....	40	90	.....
Total	9,745,100	1,781,300	5,377,400	45,735	18,316	14,311	33,027	80,87

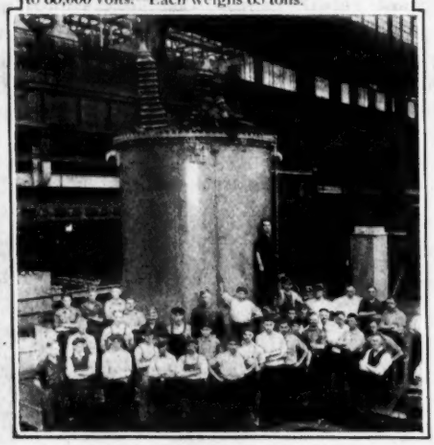
A big Pelton water-turbine being machined. This casing was so large that it had to be set up over the table of a vertical boring mill from which the uprights had been removed and a tool slide mounted on the revolving table.

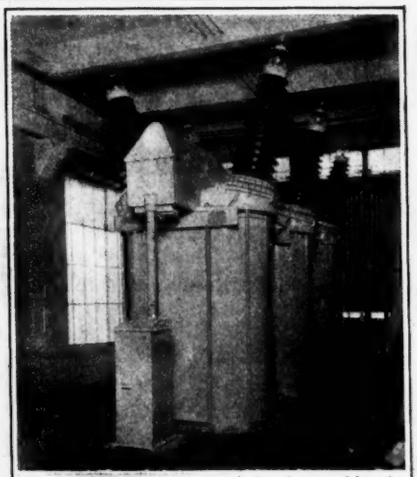




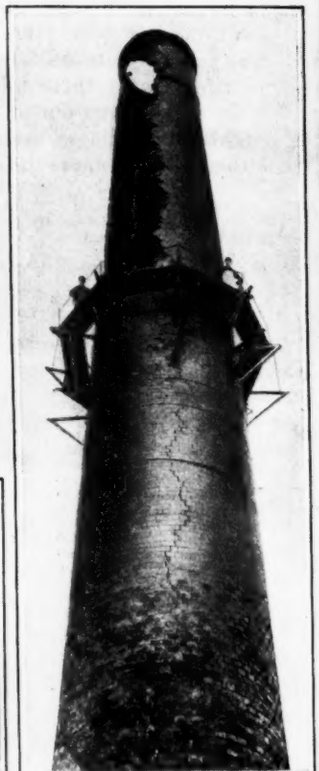
A 22 x 36-in. dry air pump driven in tandem by a 14 x 36-in. Corliss engine. Two vertical circulating pumps are set below the floor and are driven from the tail rod of the air pump by means of a bell crank connection. This unit is used with the largest hoisting engine in the world at the Quincy Mine, Hancock, Mich.

One of four 23,600-kva. Westinghouse transformers, said to be the largest in the world, built for the Cheswick Station of the Duquesne Light Co. They will step up the generating voltage of 11,500 to 66,000 volts. Each weighs 63 tons.



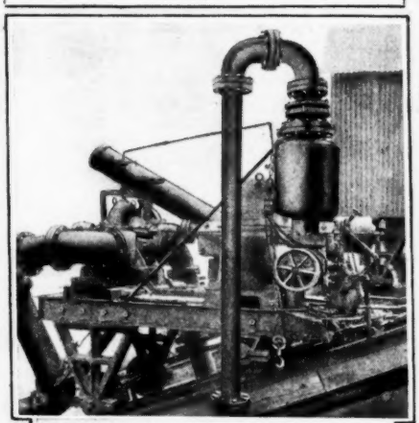


One of seven G. E. circuit breakers, said to be the largest in the world, recently completed for the Great Western Power Company of California. It will operate at 165,000 volts, 400 amperes. The overall height is 16 ft. and the weight complete 25 tons.



Repairing a 160-ft. radial brick stack without stopping the furnace, as mentioned in W. F. Leggo's paper before the American Society of Heating and Ventilating Engineers. The break, which resulted from an internal explosion, was repaired by the M. W. Kellogg Co.

Portable transformer employed in logging operations in the Northwest. The apparatus is mounted on rugged skids so that it can be transported by rail and quickly set up at the most convenient location.



The rise and fall of the Ohio River is so great that this 2,100-gal. De Laval steam-driven turbine pump was installed on an inclined railway so as to be moved up or down to keep the suction lift within reason.

EDITORIALS

States Rights Versus Federal Co-operation

IN ALL matters of large importance, such as railroad transportation, labor legislation and other basic problems of business, the question as to how far states shall go and where the Federal Government must begin in the regulation of affairs is a serious one. Just now we have this question before us in the matter of coal regulations.

The State of Indiana adopted legislation in July, 1920, giving to the newly created Coal and Food Commission of that state rather liberal powers with respect to production, distribution and sale of coal and food products. This legislation, adopted under the police powers of that state, was judged in the Federal Courts to be properly within the authority of the state, but certain regulations of the commission were determined by a different Federal Court to be unconstitutional as interfering with interstate commerce and doing certain other things which the court enjoined.

One particular aspect of this legislation is of special interest to the coal users. This is the reported result that coal users in the State of Indiana found it necessary under many circumstances to buy their coal outside the state at higher prices than those fixed by the state commission because the coal men within the state chose to ship their coal to outside destinations rather than to market it under the restrictions of the state commission. Certain steps were taken by the commission to meet this situation but, it is reported, without full success. As a result the state authorities appear to be most cordially disposed toward the proposed Federal legislation, as introduced by Senator Calder. This legislation, if enacted, would care for the coal situation—production, distribution and price fixing—on a national scale and thus prevent the difficulty that state commissions having like jurisdiction would inevitably meet from time to time.

So long as there are coal dealers or coal producers who will go to the extremes that have been noted recently in Indiana, we must have some agency for the protection of the coal purchaser. So long as even a small percentage of the operators or jobbers will take advantage of a difficult spot market, either to break coal contracts or to demand excessive prices such as have prevailed in the spot markets throughout the country for months past, we need ample powers quickly available in the hands of some reasonable Federal agency.

The coal business stands today before the public as condemned, even as the railway systems were condemned in the days when they practiced "the public be damned" policy. Not all of the coal business of the country has taken any such extreme attitude contrary to public interest, nor have the organized coal associations looked with favor upon such extreme policy. Nevertheless, the means are not at hand within the industry to cure the evil; the remedy must be applied from without, and vigorously too. The hearings now in progress on the proposed legislation before the La Follette committee of the United States Senate may reveal many defects in detail, or even of important parts of Senator Calder's bill. However, it is gratifying to note that the committee handling this legislation appears to be bent upon vigorous and prompt action in accordance with the best information that it can gather in the course of these hearings. If such Federal regulations be enacted and then the details of state production, intra-state traffic and local prices be given attention by such bodies as the Indiana commission, we can expect that the extreme penalty of emergency times will no longer need to be paid. There is no doubt that such legislation would be a bitter pill for the coal dealer and the coal producer to swallow; but *all* such must conform to reasonable legislation, even paying the penalty of inconvenience and perhaps in some cases some unnecessary detail of regulation, in order that the public may be protected against the tyranny of those within the business who will not of their own volition serve the public honestly and in the right spirit.

If we have co-operation of state and Federal authorities under such regulations, all will go well. It is to be hoped that there will be no effort to contest between the national and local jurisdictions for the right to regulate. Such contest would be most unfortunate as defeating the ends sought by both.

Hydro-Electric Plant Operation

WHERE there is an abundance of water and hydro-electric plants are operated as independent units, their operation is a simple procedure—the chief concern is to have the necessary machine connected to the busbars to carry the load. From the operation of such plants has grown an idea that water-power plants require little ingenuity on the part of the operator. However true this may be of single plants that have an abundance of water, where a number of plants are operated in series, all using the same water and the supply is limited, then the problem becomes a real one, requiring the highest engineering skill. This will be evident from reading the leading article in this issue, "Water Control on Hydro-Electric Systems," by R. C. Denny. This article deals with the hydro-electric system of the San Joaquin Light and Power Corporation, which consists of six plants of eighty thousand horsepower total capacity, utilizing a combined head of over twenty-six hundred feet. The water for this system is carried through approximately eighteen miles of open ditch tunnels and penstocks, from a storage reservoir of forty-five thousand acre-feet capacity, augmented by lesser storage capacity along the route of the water course.

This system required a large capital investment, and the return on this investment in no small measure depends on how the load dispatcher manipulates these plants to obtain the highest number of kilowatt-hours per cubic foot of water. In this system the water-power

plants are augmented by steam plants, therefore all the load that cannot be supplied by the hydro plants must be obtained by burning expensive fuel. Consequently, the necessity of skillful manipulation of the water-power system is apparent. Since it requires about six hours for the water from the time it leaves the main storage reservoir to reach the last plant on the system, careful check must be kept on stream flow at all times to assure that each plant has sufficient water to operate it, yet not an excess so that any will run to waste. In this respect operation is between two evils—water that is unnecessarily allowed to run to waste is not available for power production at low-water periods, and if there is a lack of water at the plants to supply the necessary power this must be made up by burning fuel in the steam plants.

During high-water periods, when there is an excess of water, the water-power units should be worked at their maximum capacity, efficiency being of secondary consideration. But during the periods when the amount of water available for power purposes is limited, then the question of operating the machines at their best efficiency is of prime importance. Under the latter conditions it is a problem of getting the greatest number of kilowatt-hours out of the water and not the greatest power out of the plants at any one period. There is also the problem of operating the units in the steam plants, that may be in service, loaded so that they will attain their highest efficiency.

To operate such a system successfully at its maximum efficiency, co-operation among the operating force is of paramount importance. It is not a one-man job, but a team play in which every player must be on the alert and do his part or the efficiency of the system suffers. The load dispatcher must be able to read the handwriting on the wall at all times; namely, the detection of inconsistencies in the operation of the systems. It is from these that he knows if his orders have been carried out and if the system is functioning properly as a whole.

Manufacturers' Drawings

THERE is nothing new in a complaint about the incompleteness of assembly drawings sent out by some manufacturers to purchasers of their equipment, but the matter will bear reiterating in the hope that better results may be obtained with less effort on the purchaser's part. During the war haste, expediency and shortage of labor were justifications for many shortcomings. That crisis has now past and sufficient technical help is available.

Too many chief draftsmen are so anxious to get designs out that they let very incomplete working drawings leave the office. The purchaser receiving these drawings discovers that they do not indicate definitely many items of importance to the customer. Often he cannot tell. For instance, which oil and water piping on the steam turbine is furnished by the manufacturer and which by the customer; where oil cooling and gland water inlet and outlet pipes are connected and what valves must be furnished by the customer. In the case of equipment like pumps, etc., the customer cannot tell whether companion flanges and bolts are furnished by the manufacturer at the inlet and outlet. After the equipment has been installed, the purchaser often finds that drip lines have to be provided that were never indicated on the drawings at all.

The customer, on receipt of his drawings, generally writes the manufacturer for further information, and often a long-drawn-out correspondence results before all information is available. This takes the customer's time, and the time often of executives in the manufacturer's office, all of which effort could have been saved by a small amount of additional work at the drawing board. In the interest of ultimate economy therefore it is hoped that manufacturers will scrutinize their drawings carefully before they are sent out to see that everything the purchaser needs to know is shown fully thereon.

Field of Automatic Control Extended

IN THE production, transmission and distribution of power no other means affords such ease of control as does the electrical. Not only has this inherent characteristic led to a very wide use of automatic control for electrical equipment, but many mechanical devices are made automatic by the introduction of auxiliary electric apparatus. The automatic control of electric motors has gradually extended until it includes about every kind of application, and each year sees increased use of this class of equipment. It has long been realized that where the control of an electric machine is left in the hands of an operator or whatever attendant may be at hand, there is a high probability that the apparatus will be subject to abuse. Furthermore, it is not always possible for an operator to interpret the conditions under which the machine may be operating. All this can be taken care of by a properly designed controller and the human element practically eliminated.

It is just beginning to be realized what the possibilities of automatic control are in power transmission and distribution. When the automatic substations were first exploited, it was for railway work, and for a number of years this field apparently was the one in which this class of apparatus would find its widest applications. However, the past year has seen the introduction of these equipments into industrial service. The success so far met by the equipments demonstrates a new application of automatic switching which opens the way for a field even greater than any that has so far been entered with this class of apparatus.

"Powergraphs"

IN THIS issue there appears for the first time a new department, christened for the sake of brevity, "Powergraphs." Of course *Power* has printed pages of photographs before, but for the greater part these have been tied to articles. The new department, however, will be complete in itself, and will contain "newsy" pictures showing, for instance, machines that are unusually large or of peculiar design, ingenious emergency methods of repairing or transporting machinery, new power plants under construction and innumerable other subjects of interest in the power-plant field.

The idea behind the "Powergraphs" is not new; it has been applied to the Sunday newspapers for several years and has been very popular. It is now simply applied to the field of *Power*. To do this is not altogether easy, for most engineering work is so matter-of-fact that it is difficult to find photographs of a unique or striking nature. Consequently, *Power* will be grateful to any readers who can supply it with pictures that tell an interesting story; this week's "Powergraphs" are a sample of what is wanted.

CORRESPONDENCE

Why Not Use More Producer Gas for Power?

It would appear that comparatively few American engineers know much of producer gas and its uses. Considering the limitations of the petroleum supply and the ever-increasing consumption of crude oil and its products, the subject of producer gas is very opportune. It seems to me that it is folly for this country to delude itself into believing that the fuel problem will automatically solve itself. More oil-burning ships are being built, the Diesel engine is coming into general use and the number of automobiles and trucks increased 1,700 per cent from 1909 to 1919. Enormous quantities of oil are being burned in boiler furnaces. This extravagant use of our petroleum supplies gives weight to the prediction of the Geological Survey that the oil fields will be exhausted within twenty years.

From what I can learn there has been in the past considerable investigation concerning the use of producer gas. In 1913, when the popularity of the producer-gas engine was at its height, the Bureau of Mines issued Bulletin No. 55, by R. H. Fernald, wherein the commercial possibilities of the gas producer were dealt with. At that time there were from 900 to 1,000 plants in the United States using producer and blast-furnace gases. Of a list of 722 producer plants, 610 used anthracite, 77 bituminous, 32 lignite, 1 wood and 2 oil. The advent of the oil engine practically stopped the development of the producer-gas units, but as oil becomes scarce and higher in price, the use of producer gas should be revived.

In past installations in America the producer has necessitated special fuels in order to reduce the labor charges. In general they failed to utilize low-grade fuels or waste products. How different this is from British and European practice, where many times the American total of producer-gas plants are in successful operation. While in Australia from 1899 to 1912, I watched the development of the producer-gas power plants, especially from 1904 to 1912, using British makes.

Australia is a country with little water power and no petroleum so far developed, but with plenty of high- and low-grade coals and wood, so the gas producer had a good chance to show its efficiency and reliability. This it did, consuming charcoal, coal, coke and firewood. Of course there were troubles and vexations, but much of this, like what happened in America in about the same years, arose from inexperience. I had also seen some very economical plants in New Zealand, especially at the Waihi gold mine, where the total cost, using bituminous coal, was only twelve cents per horsepower-day. In Western Australia a lignite was used with success. Since 1912 a down-draft producer burning 6-ft. lengths of wood has been developed. This consumes 30 per cent less fuel than one using charcoal, and there is a general reduction of 30 per cent in costs.

How is it, I would like to ask, that American producer-gas plants failed to utilize low-grade fuel or waste products, when British installations work so well on such materials as charcoal, coconut shells, cocoa husks, coffee husks, coke, cotton seed, coir dust, corn cobs, olive refuse, peat, rice husks, sawmill refuse, sugar-cane refuse, spent tanbark, tea refuse, and wood? In the United States there are hundreds of thousands of tons of such waste, easily collected, burned, or dumped into the sea every year. This should be converted into energy of some form. Consider the almost criminal waste at our sawmills, cane-sugar mills, flour mills, the neglected peat-beds of North Dakota, and a hundred and one other waste products. Recently, when in California, I saw huge dumps of rice husks being burned because the mill owners did not know what to do with them, not realizing that there was enough fuel being wasted daily to drive all their machinery.

Several British firms have specialized in suction gas producers and engines for half a century, and have wonderful records in designing such plants to make producer gas from the byproducts mentioned. Why cannot it be done in America?

Tuckahoe, N. Y. M. W. VON BERNEWITZ.

Faulty Setting of Motor

A 7½-in. three-phase 440-volt motor, belted to a generator, had been giving considerable trouble by rattling violently when running at full speed. The generator appeared to be in perfect condition, since it revolved smoothly when disconnected from the motor. No loose bolts could be found on either machine either on the end plates or on the bases. The bearings showed no appreciable signs of wear and were well oiled. Insulation tests on the motor gave no results.

On closely observing the motor while starting it slowly, it was noticed that the armature would drift over toward the pulley bearing and then rebound. As the speed increased this action became more and more rapid, causing the rattling that had been observed. By testing with a level, the motor base was found to be ⅛ in. low on the pulley end. After leveling up the motor, no more trouble was experienced. This emphasizes the importance of carefully setting a motor.

Boston, Mass. E. S. BAXTER.

The Speed Limit of Ball Bearings

The article on "The Speed Limit of Ball Bearings," by W. J. A. London, in the issue of Dec. 7, 1920, treats of a very important feature of ball-bearing operation.

Continued use of ball bearings applied to various types of machinery has proved their suitability, both from an operating and from an economic point of view. It is only when high speeds are reached that their behavior becomes uncertain. Furthermore, at high speeds load seems to have little effect on the life of

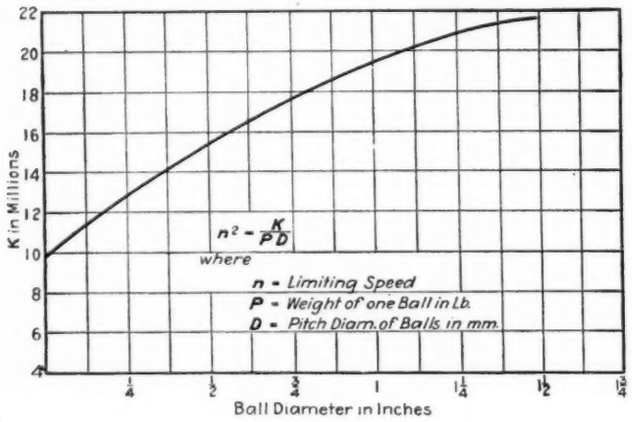


CHART FOR VALUES OF K

the bearing. This phenomenon is well known to the ball-bearing fraternity, and it is rather peculiar that since the effect of speed on capacity has been known, no attempts have been made to change the design to meet known conditions.

Most of the ball-bearing manufacturers are continually carrying out tests for the purpose of securing data to help them revise their load tables from time to time, but improvements to date in the ball bearing consist largely of refinements in manufacture only.

A chain is as strong as its weakest link, and the weakest link in the ball bearing is the retainer. It is agreed that, despite their failings, retainers are a regrettable necessity. They are made of various materials and in many styles, but they all possess the objectionable feature of unbalance at high speed. As it is practically impossible to balance a retainer both statically and dynamically, the problem becomes intricate, but not beyond the reach of a satisfactory solution.

Having eliminated retainer unbalance, we have left the problem of lubrication. Ignoring the retainer, a ball bearing would operate quite satisfactorily without lubrication, owing to the fact that a lubricating oil film is not possible between balls and races. This particular point is further dwelt upon in the writer's paper, "The Lubrication of Ball Bearings," presented at the 1919 annual meeting of the American Society of Mechanical Engineers. The writer does not anticipate any lubrication trouble with a retainer intelligently designed. The retainer loads given by Mr. London are approximately correct. In fact, when the outer race is rotating, as in loose pulleys, etc., the load becomes much greater than that given by him.

After running high-speed tests for a number of years on ball bearings, one company obtained the following approximate formula for the limiting speed of a ball bearing:

$$N^2 = \frac{K}{PD}$$

where

N = Limiting speed of bearing;
P = Weight of one ball in pounds;
D = Pitch diameter of balls in millimeters;
K = Constant depending on ball size.

The chart gives the constants for varying ball sizes.

This formula is of course incorrect, as it ignores the retainer. The limiting speed is that point where the increase of temperature with speed is no longer constant.

H. R. TROTTER.

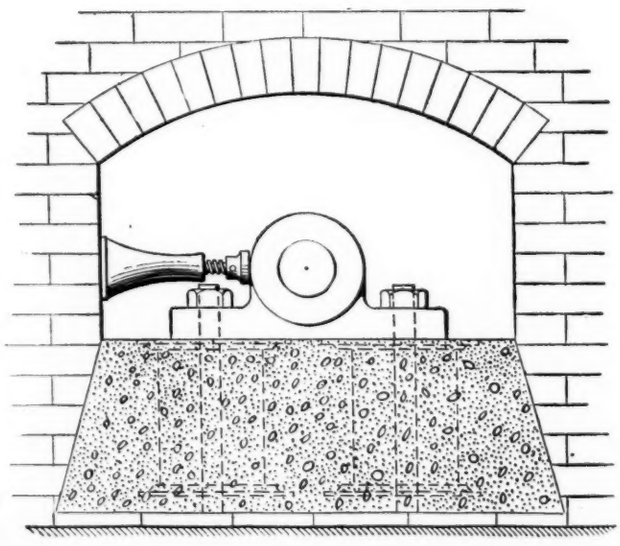
Lester, Pa

Emergency Outboard-Bearing Repair

Our prime movers consisted of a 24 x 48-in. Corliss engine running at 72 r.p.m. and belted to an alternator, and two turbines, each geared to two alternating-current generators in tandem. Our heavy, or day, load could be carried by any two of these units.

The Corliss engine was in need of overhauling. The outboard bearing was supported in the brick wall of the building. The brickwork had become soaked with oil and was soft for about 30 in. below the bearing, and it became necessary to replace it.

At 4 p.m. on Thursday the flywheel shaft and crank had been jacked up and the soft brickwork torn out. The piston and piston rod and other parts of the engine had also been removed, when the shaft of one of the



PIPE COLUMNS AND FLANGES FOR BEARING SUPPORT

turbines broke off within the recessed hub of the turbine wheel. Repairs to the turbine required new parts, which would require some time to obtain. The Corliss engine could be quickly reassembled, but it would require time for the concrete of the new masonry under the outboard bearing to set.

To overcome this difficulty, I hit upon the plan of transmitting the weight of the outboard bearing to the solid brickwork by two columns of standard 10-in. pipe fitted with cast flanges. We were able to obtain the necessary pipe and fittings from local stocks and about 3 p.m., Friday, the columns were on the ground, and

at 6 p.m. we had them in place and concrete poured in and about them, as indicated in the illustration. By Saturday morning we had the flywheel shaft and crank let down and lined up ready to rebabbitt the main bearings. Sunday morning at 10 we had the engine turning over under steam, and on Monday morning it carried its regular load.

To assist in counteracting the pull of the belt until the foundation had a chance to set, we placed a jack between the outboard bearing and the brick wall as indicated.

H. A. WARD.

Ithaca, N. Y.

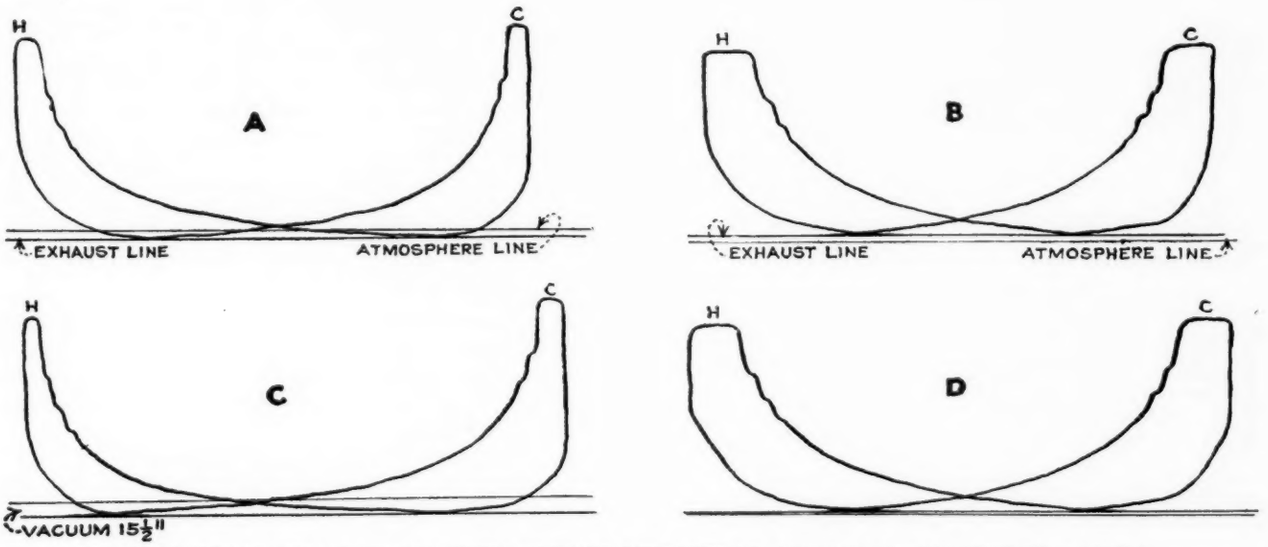
Running Vacuum Heating System Condensing

The accompanying diagrams are not submitted for criticism as to the general condition of the engine, for I know that the piston as well as the steam and exhaust valves all leak, especially the exhaust valves, and as soon as the company can spare the engine long enough, I expect to have the cylinder and exhaust-valve seats rebored, a new piston and valves fitted and the gridiron steam valves reseated.

I have not seen anything in print about running an engine condensing on a vacuum heating condensing return heating system. As this plant has just been equipped with such, I have been experimenting some to see just what advantages can be gained from such a system. A vacuum heating system is not new to me, but this one is the first plant piped up so as to allow running condensing and still heat the buildings at the same time. It required much study to assure myself that the idea could be a success in actual operation, but it has proved to be even more so than I had expected. It just pulls the vapor through the radiators, and the heat is radiated from them while the engine runs condensing on a few inches of vacuum.

The greater the vacuum the less power is required in the engine, and to satisfy my own curiosity on this point I took the indicator diagrams shown. The diagram shown by *A* was taken with a 12-in. vacuum on the engine and 25½ in. at the vacuum pump on the end of the return line. The engine is 22 x 42 in., runs 70 r.p.m., scale 60, boiler pressure 95 lb. gage. The cutoff is very short as the load is usually light at about 2 p.m. In order to see the difference in horsepower effect and change in the cutoff, I turned the exhaust to the atmosphere and took diagram *B*, which shows the exhaust line and the atmospheric line. The atmospheric line was drawn before the diagrams were made, by turning the drum around by hand with the pencil against the paper so as to make sure the three-way cock did not leak and give a high atmospheric line. The boiler pressure is 95 lb. on this card also. It will be seen that the point of cutoff is much longer than in *A* diagram, although the load averaged the same as usual on light running.

Not satisfied with this, I ran the vacuum up to 26½ in. and took diagram *C* with 95 lb. boiler pressure and 15½ in. vacuum at the engine. The point of cutoff is shorter than that shown by diagram *A*, and the difference between the exhaust and atmospheric lines clearly shows the difference in the vacuum, and all the while the radiators continue to radiate the heat and keep the buildings warm with an outdoor temperature of 28 degrees.



INDICATOR DIAGRAMS TAKEN WITH VARIOUS DEGREES OF VACUUM AT THE RETURN VACUUM PUMP AND AT THE ENGINE

When diagram *D* was taken the steam pressure had dropped to 94 lb., which is hardly noticeable. The vacuum had been lowered to 18 in. on the pump and the back pressure built up to ¾ lb. by weighting the back-pressure valve. The point of cutoff is nearly the same as shown on diagram *B*, although the exhaust line and the atmospheric line show less back pressure on the *D* than on *B* diagrams, which were taken with the engine exhausting to the atmosphere. Comparing *D* with *C* diagrams, the point of cutoff is only about one-half as late as in *D*, a saving of almost one-half the volume of steam generated, and makes it possible to heat the buildings with less waste of steam, as the extra volume exhausted, as indicated by diagrams *D*, could not all be used in the heating system and condensed with only 18 in. of vacuum on the return pipe at the pump. So it would appear that even though the pump exerted a pull of 18 in. of vacuum on the condensate in the return pipe, there is more condensate in the pipe itself with the lower vacuum, and the resistance of this condensate is

sufficient to require ¾ lb. back pressure on the engine to force the condensate through the radiator return valves with the lower vacuum.

I have seen large office buildings run with a condensing or vacuum heating system and the compound gage holding at zero or at vacuum at the engine and only 4 to 6 in. of vacuum at the end of the return pipe. Of course the condensate would return by gravity from the radiators in the top part of the building, and no great amount of vacuum was required to bring it back to the boiler room, as would be the case if it were necessary to pull the condensate 400 or 500 ft. through a horizontal pipe line.

It did not appear to me that the steam plant running a vacuum heating system from the engine at zero pressure was getting the greatest economy out of the plant or the fuel used. If it is necessary to use a large amount of city water to condense the steam coming back to the vacuum pump there will be little saving in the system. In any case the amount of radiating surface must be large enough to use most of the exhaust steam from the engine in order to run condensing entirely, and then if sufficient heat is supplied the vacuum can be carried as low as possible without reducing the volume of steam exhausted from the engine below that which is necessary to heat the buildings to such a point that live steam would have to be turned into the heating system with the exhaust steam to make up for the shorter cutoff and decreased volume due to the greater vacuum carried. It would be better in such a case to carry a lower vacuum, say zero or one or two inches.

I am satisfied that a great saving can be made by the use of a vacuum-heating system over the old back-pressure system. But a great volume of steam will escape if the cutoff is made later, thus exhausting a greater volume of steam than the radiators are capable of condensing. The condensing of the steam must be done in the radiators and pipe lines in order to utilize the heat units, and not at the vacuum pump, as is the case with a condensing engine.

It is my policy to build up a vacuum in the system by starting the vacuum pump a few minutes before the steam is turned into the heating mains. Then only water will return, with possibly a small amount of air and vapor. But little vapor will come through a return pipe full of water except with a large volume of air, which will destroy the vacuum. A closed heater is necessary or large pipe supply mains to allow for live steam to expand if live steam is also used, as at night when the engine is shut down. R. A. CULTRA.

Cambridge, Mass.

Does a License Law Help?

In reply to questions asked by R. G. Summers in the Dec. 28 issue of *Power*, I will state that the license laws of Massachusetts do not bar a real engineer who knows his business.

About three and a half years ago I decided I had worked where anyone could call himself an engineer about long enough, and I resolved to go to Massachusetts and do something until I could get an engineer's license. I knew nothing about the license laws or what the examination was to be like. I came to Webster an entire stranger and obtained a job as all-round mechanic in a large factory.

As soon as I learned how to go about it, I applied for an examination for a first-class engineer's license, and did not get it, because I knew only a small part of what I supposed I knew. I applied again in ninety days, and upon that examination I received a second-class engineer's license and at once secured a job as chief, which paid better than any I ever held before, and it was only an operating job at that.

Fifteen months later I received a first-class engineer's license and in three more months was made master mechanic and chief engineer of the factory, which position I still hold.

I learned more while plugging for a license than I ever thought there was to know about engineering, and also learned how little I ever would know compared with the knowledge there is to be gained of the subjects involved in the engineering game.

My license and my position were obtained by reason of my own ability, for I knew not a soul in this community three years ago; so the fact cannot be credited to pull or anything of the sort.

I submit these statements for Mr. Summers' benefit, as proof that a man who has the ability and who is willing to learn that which any man should know to be allowed to have charge of a steam plant, has nothing to fear from the Massachusetts engineers' license laws.

I have worked with just such engineers as the one Mr. Summers tells about and they held first-class licenses, but the percentage of those who hold such licenses and are as stupid or intemperate as the one mentioned is very small; and I can tell you that mighty few of them are getting even third-class licenses today; for a man must prove himself reliable as well as competent if he gets any kind of a license from the examining boards of this state today.

There is no surer or better way to raise the standard of the engineer than to insist that he become educated along his line of work, and that is exactly the purpose of those who uphold engineers' license laws, and they are going to succeed, so the sooner we fall in line and get the "dope," the better it will be for us.

I extend to Mr. Summers a cordial invitation to come to Massachusetts and try for a license, and I will give him a job at a living wage until he has had a reasonable time to secure his license, and if he gets at least a second-class engineer's license, I will either employ him or get him a position, and I will bet all I have that he will change his mind in regard to our engineers' license laws before he has been here two weeks. I make this offer in good faith, and I would like to correspond with Mr. Summers directly, and if I can be of assistance to him or any other engineer, I shall be glad to help them.

Webster, Mass. L. M. REED, M. M.
Chase Mills, American Woolen Co.

Steam Turbines—A Correction

My attention has been called to an unintentional misstatement of fact in my article, page 9, in the Jan. 4 issue of *Power*, on Steam Turbines. It is stated there that "considerable attention has been given to lubrication problems both for steam turbines and reduction gears. Allis-Chalmers Co. is incorporating a batch-filtration system on all large units."

This should have stated that the Allis-Chalmers Co. is furnishing a continuous bypass oil-filtering system on all large units. A. G. CHRISTIE.

Baltimore, Ind.

INQUIRIES OF GENERAL INTEREST

Operation of Ejector Condenser—What is the principle upon which an ejector condenser operates? E. C.

An ejector condenser operates on the same principle as an ordinary ejector. Exhaust steam from the engine enters the ejector through a series of orifices and is condensed by the cooling water, which results in imparting to the water a high enough velocity to discharge it against atmospheric pressure.

Damage from Water in Cylinder—Would breaking of an engine cylinder from presence of water be more likely to occur with a D slide valve or with a piston valve? G. R. W.

A "smash" is more likely with a piston valve than with a flat D slide valve because, with a piston valve, the only relief passage for the water is the chance amount of port opening at the time the piston compresses the water in the cylinder; whereas, a D slide valve can be forced away from its seat and the water can be vented to the steam chest.

Oil Engine Cannot Be Started with High Air Pressure—When it is attempted to start our Diesel engine with the air-injection pressure around 900 lb. per square inch in the fuel valve, the engine fails to fire, but with pressures of 600 to 700 lb. the engine fires promptly. Why is this? R. M. A.

The cylinders of your engine are probably worn, causing a fairly low compression pressure and a low final temperature. If the injection air pressure is high, the chilling action from expansion through the nozzle lowers the cylinder temperature below the ignition point of the fuel oil.

Order to Cut Boiler Out of the Line—When there is a battery of boilers each provided with a superheater and each one connected to a saturated-steam line and a superheated-steam line and an order is given to cut a certain boiler "out of the line," would the order be complied with by only cutting the boiler out of the superheated-steam line? J. C. B.

An order to cut a boiler out of the line is commonly employed and understood to signify cutting the boiler out of common service and connection with other boilers in the same battery; and unless some particular line is specified, the order should be construed as direction for the boiler to be cut off from the saturated-steam line as well as the superheated-steam line.

Grounding in a Three-phase Generating Plant—Is it good practice to ground the steel framing of the plant, as well as the instrument casings and transformer tanks, etc., on the same ground plate as the generator neutrals? C. R.

This is permissible and is the practice in some plants. But it is considered better practice to have a separate ground for the generators. No matter how much care is taken to keep the resistance of the generator ground as low as possible, it is practically impossible to prevent the voltage drop in the ground from reaching at least 200 volts on dead short-circuit. In case the same ground is used for the station, this voltage backs up all over the plant, and anyone touching any apparatus may receive a shock, and delicate instruments be damaged by this tension. Furthermore, there is always some chance, although remote, that the ground may accidentally dry out or the connection to the plate may become corroded and broken, in which case a short-circuit in one phase may give full-line voltage on the whole grounding system of the plant, with great danger to life and apparatus.

Measurement of Three-phase Power—How can the power consumption of a three-phase induction motor be measured with an ammeter and a voltmeter? B. S. M.

It is not possible to measure power in an alternating-current motor circuit with an ammeter and a voltmeter unless the power factor is known; for the power factor changes with the load, with the result that the current is not proportional to the load. For example, the motor in question might take 40 amperes at full load, 32.5 amperes at three-quarter load, 25 amperes at one-half load, 18 amperes at one-quarter load, and 14 amperes at no load. Therefore reduction of load from full to three-quarters decreases the current by 7.5 amperes, whereas from one-quarter to no load decreases the current only 4 amperes.

Apparent Inequality of Cutoff—What would cause a difference in the relative length of cutoff shown by indicator diagrams taken from a single-eccentric Corliss engine with no change of adjustments except setting the eccentric ahead of its former position? V. W. P.

For the same load, moving the eccentric would slightly change the relative points of cutoff by introducing a change in the angularity of the valve gear; and diagrams taken from opposite ends of the cylinder may appear to indicate greater inequality of cutoff on account of greater difference of governor positions when the diagrams are made, due to the hunting action of the governor. The true relative cutoff of opposite ends of the cylinder should be determined by indicating them simultaneously as nearly as possible, with the governor held in a fixed position, long enough to strike the diagrams.

Effect of Reduction of Diameter of Eccentric—What would be the effect in operation of an engine eccentric if ¼ in. was turned or worn off the diameter of the eccentric? H. R.

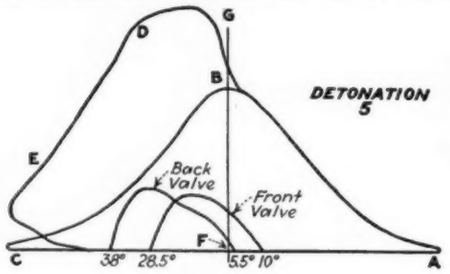
A quarter-inch reduction of diameter of the eccentric, without equal reduction of the bore of the eccentric strap, would give rise to ½ in. lost motion at each end of the stroke of the eccentric rod, with a corresponding reduction in the length of valve travel. But if the eccentric straps are bored out to as snug a fit as they first had with the eccentric, and the length of the eccentric rod, measured from the center of the eccentric to the pin in the end of the rod, is made the same as it was before reduction of the diameter of the eccentric, then there will be no change from the original travel of the eccentric-rod pin and the original length of rocker arms and valve rod will give the original valve travel.

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Detonation in Diesel Engines*

By C. J. Hawkes, Eng. Com. R.N.

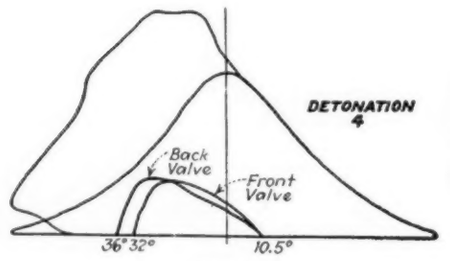
In nearly all engines of the opposed-piston type which the author has seen running, the injection of the fuel oil has been accompanied by slight detonation. These engines, however, did not run much above 200 r.p.m., whereas the experimental opposed-piston engine referred to in this paper was run at speeds up to 360 r.p.m. In certain circumstances the detonation of the fuel in the experimental engine was



DETONATION 5

R.P.M. 296
B.H.P. 296
M.I.P. 129
Blast 1,350
Fuel 0.468 lb. B.H.P.-Hr.
Mech. Eff. 66%
Exhaust Clear

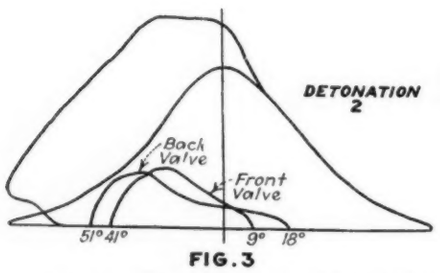
FIG. 1



DETONATION 4

R.P.M. 306
B.H.P. 306
M.I.P. 127
Blast 1,350
Fuel 0.470 lb. B.H.P.-Hr.
Mech. Eff. 66%
Exhaust Clear

FIG. 2



DETONATION 2

R.P.M. 300
B.H.P. 300
M.I.P. 131
Blast 1,125
Fuel 0.524 lb. B.H.P.-Hr.
Mech. Eff. 64%
Exhaust Slightly Shaded

FIG. 3

FIGS. 1 TO 3. TYPICAL COMBUSTION DIAGRAMS

most marked, and although it did not appear to be harmful, it would, if heavy, be rather distressing in a multi-cylinder engine of this design.

Three typical combustion diagrams, obtained with various shapes of cams, are shown in Figs. 1 to 3. The valve-lift diagrams for the front and back fuel valves are also shown on the same angle base. An arbitrary figure for the intensity of detonation and other particulars are given against each combustion diagram. Although in the experimental opposed-piston engine there was no separate timing gear, and therefore it was not possible to modify the "timing" of the fuel valves when the engine was running, the fuel cams were adjusted so that the maximum pressure was limited to about 630 lb. per square inch.

In Fig. 1, with short-period cams in use, *ABC* is the diagram obtained when the engine was running at about 300 brake horsepower, but with the fuel momentarily cut off. *FAB* therefore represents, on an angle base, the compression curve, and *BCF* the expansion of the air previously compressed. The line *FG* gives the position of the indicator drum corresponding to the inner dead center; that is, when the pistons were at the end of the compression stroke. *ADE* represents the combustion diagram. In Fig. 1 the detonation figure is 5 on the arbitrary scale adopted. In Fig. 2 the cams give a slightly greater period of opening. Fig. 3 is a combustion diagram with long-period cams in use. Here the fuel consumption is greater and the detonation less than with the short-period cams.

From the combustion diagrams shown in Figs. 1 to 3 the pressures in excess of the pressures given by the no-fuel compression-expansion diagrams were plotted on an angle base, and from these curves the rates of change of pressure were obtained. The upper chart in Fig. 4 shows the rate of pressure-change curves. It will be seen that heavy detonation is accompanied by a high rate of change of pressure occurring just after the dead center. From the combustion diagrams temperature-entropy diagrams were also constructed for comparative purposes, with the assumptions that the temperature of the air charge at the beginning of compression was 200 deg. F. and that the weight of the working fluid was constant throughout the cycle. Using the temperature-entropy diagrams, the heat supplied and the temperatures throughout the cycle were plotted for each case, and from the heat-supply curves the rate of the supply of heat was obtained. The lower diagram in Fig. 4 shows the curves of rate of heat supply. It will be seen that in the case of the combustion diagram shown in Fig. 1, where the detonation was heavy, the rate of the supply of heat was greater than in the case of low-detonation diagram, Fig 3.

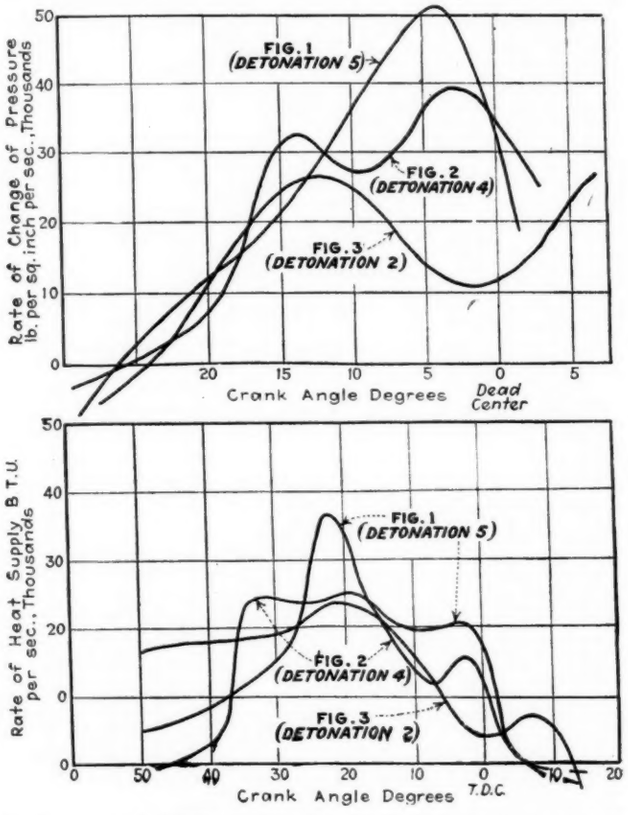


FIG. 4. HEAT-SUPPLY AND PRESSURE-CHANGE DIAGRAM

From the various diagrams constructed the following points were clearly indicated:

1. An increase in the rate of the supply of heat—that is, in the rate of combustion of the fuel—resulted in heavier detonation.
2. In the case of low-detonation diagrams heat was being supplied later in the expansion stroke than in the case of the high-detonation diagrams.
3. The maximum and mean temperatures of the cycle were greater in the low-detonation diagrams than in the high-detonation diagrams.
4. The thermodynamic efficiency was higher in the case of the high-detonation diagrams than in the case of low-detonation diagrams (this agrees with the fuel consumptions recorded).

*Extract from paper read before the Northeast Coast Institution of Engineers.

From the experiments that were carried out, it was clear that detonation was a function of the speed of injection with the particular oil fuel used, but when working at mean indicated pressures just above 130 lb. per sq.in., an increase in the quantity of fuel oil injected, other conditions remaining the same, tended to decrease detonation—although in this instance the exhaust did not remain colorless. Also, a reduction in the quantity of fuel injected tended toward decreased detonation. Texas fuel oil was used during all these tests. There has been no opportunity to experiment with the object of determining to what extent the intensity of detonation is affected by the brand of fuel oil used.

The mixture of fuel oil and air which is blown into the compression space through the two fuel valves is not at first inflammable, and it seems reasonable to suppose that ignition does not occur until the speed of the incoming charge is reduced, its temperature raised above the ignition point of the fuel oil and the distribution such that an inflammable mixture is obtained. When heavy detonation occurs, therefore, it is probable that there is a combination of circumstances favorable to rapid combustion; that is, by the time the incoming charge of fuel and blast air has had its temperature raised above the ignition point of the fuel, either of admixture with highly heated air in the cylinder, by radiation from the small portion of fuel vapor which begins to burn on the fringes of the jets or by the formation of a pressure wave (as in the case of the aircraft engine), a large proportion of the fuel has been distributed generally in the compression space and an inflammable mixture obtained, with the result that combustion is extremely rapid.

It has been mentioned that when working at high mean pressures an increase in the quantity of fuel injected, other conditions remaining the same, tended to decrease detonation. In this instance it is probable that the additional fuel injected resulted in the formation of pockets too rich in fuel, and that combustion was consequently delayed. Although many experiments were carried out, it has not so far been possible to run at high powers with Texas fuel oil at comparatively low fuel consumptions and at the same time avoid the detonation effect entirely. Generally speaking, a reduction in the intensity of detonation resulted in increased fuel consumptions.

Electric Ship Propulsion Discussed

The question of whether reduction gearing or electricity is better for ship propulsion was the principal subject of discussion at a joint meeting of the New York sections of the American Institute of Electrical Engineers and the American Society of Mechanical Engineers, held on Jan. 28. The chief features of interest in a lengthy program were an address by Admiral Benson, chairman of the United States Shipping Board, and two papers on ship propulsion by Eskil Berg, of the General Electric Co., and W. E. Thau, of the Westinghouse Electric and Manufacturing Co.

Admiral Benson pointed out the need of perfecting every possible device for making our merchant ships more efficient, in order that we may hold our present position in world trade and eventually make it stronger. He gave it as his opinion that the system of ship propulsion that will ultimately prove superior to all others for mercantile vessels as well as warships is the "Diesel-electric" type. He said he had the utmost confidence in the new merchant ship "Eclipse," the electric propulsion machinery of which was described in *Power* for Nov. 2, 1920; that he had, in spite of criticism, sent this vessel on its first voyage all the way to the East Indies; and that the latest report, from Singapore, stated there had not been a bit of trouble since leaving port.

Mr. Berg, in his paper, "Turbine Reduction Gears versus Electric Propulsion for Ships," said that the question depends entirely upon the type and operating conditions of the vessel concerned. He pointed out that the Navy Department has decided upon electric drive for all the larger vessels, but he described the geared turbine as being more advantageous in fast destroyers and light cruisers where the propeller speed is always high. In the case of mercantile ships he felt that each individual installation deserves study and that no general rule can be drawn except, possibly, that electricity is better for fast passenger liners.

In summing up, the speaker gave the following points in favor of electric drive.

It affords easy reversal at full power by electrical connections without reversing the turbine.

It makes it possible quickly to detect trouble and to check up on fuel consumption, by means of voltmeters, ammeters, and other accurate electrical instruments.

It is practically noiseless.

Electrification of mills and factories has greatly reduced maintenance cost and is expected to have the same result on ships.

It makes possible economical cruising at reduced speeds.

In case several generating units are used, one may be shut down without impairing the efficiency of the complete installation.

As the turbine is never reversed and there are no reverse blades dragging, a higher degree of superheat and higher steam pressure may safely be used.

The omission of reversing blades shortens and lightens the turbine shaft and thus permits higher speeds and longer bearing life.

The generating units may be put in any convenient place, near the boilers, for instance, and the motor at the extreme stern if desired, thus eliminating the space requirements and bearing troubles of a long propeller shaft.

Arrangements may be made to drive the main auxiliaries by electricity, so that if the main generating unit breaks down, steerageway may be maintained by the auxiliary unit.

Comparing the efficiency of electric drive with that of gear drive, Mr. Berg declared that there is little difference in fairly large installations, such as 3,000 hp. and over. He gave about 92 to 94 per cent as representative efficiencies of the transmission apparatus, consisting of gears in one case and a generator and motor in the other. He put the cost of electric drive slightly higher than for gear drive.

Mr. Thau's Paper on "Electric Propulsion of Ships"

W. E. Thau, in his paper, "Electric Propulsion of Ships," agreed with Mr. Berg that the type of drive depends upon a number of different factors, so that no system of propulsion can well be recommended for general use. He regarded electric drive as a logical and successful development, but declared that the geared turbine drive has come to stay and has a legitimate field. He described the internal-combustion or Diesel drive as offering possibilities superior to those of any other type. Mr. Thau said, however, that the development of high-speed Diesel units for electric drive has not been perfected in sizes that will permit a drive in excess of approximately 6,000 hp. He advocated the use of a number of small, high-speed Diesel engines so as to obtain greater flexibility and reserve power.

In the discussion that followed the papers, G. A. Pierce, of the William Cramp & Sons Ship and Engine Building Co., defended strongly the use of turbine reduction gears and criticized electric drive, particularly for its complexity and the difficulty of training men to handle it at sea. He even questioned the superiority of electric drive at cruising speeds over a well-designed turbine installation containing geared cruising turbines. He asserted that the full-power reversing made possible by electric drive is unimportant, because no more than about one-third of full power can properly be utilized in stopping a ship and no more than that is needed in backing. He then read a statement from J. F. Metten, chief engineer of the Cramp company, which said that proponents of electric drive generally compare the newest and best examples of that system with selected failures of gear drives, and that in his opinion the latter type will eventually prove its superiority.

Commander C. A. Jones, of the United States Navy, on the other hand, said that as far as capital ships in the Navy are concerned, electric drive has come to stay, and also that no great difficulty has been encountered in training the engineer force to handle the electrical machinery involved.

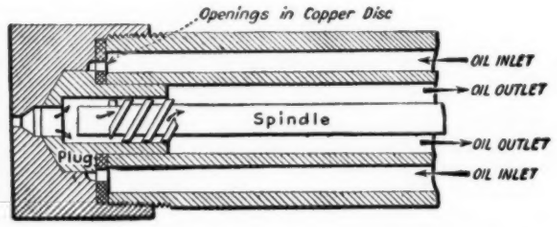
Advances in Oil Burning*

Single Burner Consumes One Ton of Fuel Oil Per Hour

By Ernest H. Peabody

The United States Navy is pointing the way to future development in oil burning. In co-operation with leading mercantile interests who are manufacturing equipment for the Navy, they are not only experimenting in the use of heavy viscous oil, but are demanding larger units and greater individual capacity both in boilers and in oil burners. I predict that this increase in size and rate of forcing will mark the trend of future development in the merchant marine. Today there has been no marked advance along these lines in the merchant service, notwithstanding the fact that the number of oil-burning ships has been enormously increased and our imagination has been stirred by the fitting up for oil fuel of some of the largest transatlantic liners.

It has been generally believed that the pounds of fuel oil delivered through a single atomizer should not exceed 1,000



SECTION THROUGH THE FISHER MECHANICAL OIL BURNER

pounds per hour. With steam atomization the efficiency of the furnace usually showed a decided decrease with an increased oil delivery through the burner. This does not apply to so great an extent with burners employing mechanical atomization.

A new record in oil per burner per hour was established on Sept. 17 by Commander Purnell, when three Babcock & Wilcox burner units were tested. The oil used was 19.9 Baumé. The test was of one hour's duration, but followed several hours' steaming during which the individual burner capacity was pushed up to 2,000 lb. per hour. The record for the hour shows 2,238 lb., while in the last half-hour the rate of combustion per burner reached 2,287, thus giving a safe margin over one ton of oil per burner per hour.

Owing to the three burners only being in operation in the large furnace, it is to be noted that the oil burned per cubic foot of furnace volume was reduced to 8.9 lb. per hour. The table gives the results of several of the tests.

Limitations of the Ordinary Type of Mechanical Atomizer

It is well known that the mechanical atomizer of the usual design has a decided limitation in range. Unlike the steam atomizer, it cannot be operated at low capacity if it is designed for a high one. The lower limit with the oil pressures ordinarily used is approximately one-half the upper. The reason for this is very simple. The burner depends for its atomizing effect on centrifugal force induced by giving the oil a rapid whirling motion in the central chamber of the tip. This whirling motion, in turn, is produced by delivering the oil to the central chamber through eccentric passages, or small channels substantially tangential to the walls of the chamber. All the oil that enters the chamber though these channels finds an exit through an orifice concentric with the axis of rotation. Thus as the capacity of the burner is reduced by the obvious method of reducing the oil pressure, there is a lower velocity through the channels and friction losses become more apparent, until finally the spraying effect is reduced till the oil issues from the tip in a solid stream or as a spray too coarse and uncertain to give the desired results.

A radically new plan, however, has been devised which promises very satisfactory results. This consists of maintaining the whirling motion in the central chamber of the tip undiminished, whatever may be the capacity desired of the burner; in other words, instead of delivering through the orifice all the oil that enters the burner chamber, a part of the oil supply is diverted or bypassed from the central chamber and returned to the pump suction, and the actual effective capacity or amount of oil that is sprayed into the furnace depends merely on the proportion of the oil that is bypassed to the total amount entering the burner. Thus, as the amount of oil entering the central chamber through the tangential slots remains at all times at the maximum, the whirling of the oil and the atomizing effect remain also at a maximum so that a perfect spray is secured whatever the capacity, at low powers as well as at the highest rate. This method of spraying is the invention of Commander J. O. Fisher, U. S. N. It is believed that the wide range in capacity will make the burner especially useful for fluctuating loads or in any installation where it is now necesssary to change the tips or close off a portion of the burners. The design is shown in the accompanying illustration.

SUMMARY OF TESTS ON WHITE-FORSTER BOILER

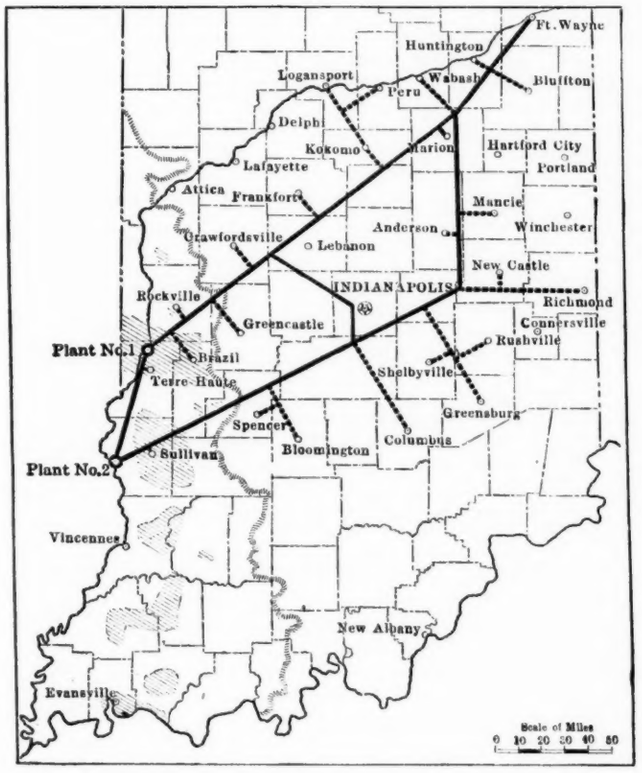
Test number	44–8		
Date	9-29-20	9-17-20	9-17-20
Barometer-in. of mercury	....	30.10	30.10
Duration of test-hours	3	1	1
Number of burners	3	3	3
Type of burners	B. & W.	B. & W.	B. & W.
Type of air registers	"Lodi"	"Lodi"	"Lodi"
Steam pressure on drum, lb. per sq.in.g	284.9	281.3	285.8
Steam pressure below stop, lb. sq.in.g	279.8	267.2	272.8
Superheater temperature, deg. F	462.4	487.8	487.4
Feed water temperature, deg. F	200.1	200.5	200.4
Water evaporated, lb. per hr	43,978	86,625	89,270
Oil burned, lb. per hr	3,054.4	6,714	6,862
Oil pressure at burners, lb. sq.in. g	204.3	324.6	341.4
Oil pressure on return line, sq.in.g	.....	.....	.....
Oil temperature at burners, deg. F	155.9	147.2	146.8
Fireroom temperature, deg. F	102	100.9	.....
Stack temperature, deg. F	567	667	709
Fireroom pressure, in. of water	2.87	6.94	7.12
Smoke (Ringelmann Scale)	0–1	1	1
Flue gas, inner pass, CO2, per cent	13	11.3	12.8
Flue gas, inner pass, O2, per cent	3.3	5.3	3.0
Flue gas, inner pass, CO, per cent	0.0	0.0	0.0
Calorific value of fuel, B.t.u., lb	18,939	18,939	18,939
Superheat, deg. F	48.22	76.0	75.6
Factor of evaporation	1.1018	1.1182	1.1173
Actual evaporation per lb. of oil, lb	14.399	12.902	13.009
Equiv. evaporation per lb. of oil, lb	15.855	14.427	14.535
Oil burned per sq.ft. H.S., lb.-hr	0.404	0.888	0.908
Oil burned per cu.ft. F.V., lb.-hr	4.067	8.940	9.138
Oil burned per burner per hr., lb	0.1009.1	2,238	2287.3
Boiler and furnace efficiency, per cent	81.29	73.92	74 47

In the annual report of the Supervising Inspector General of the Steamboat Inspection Service for the fiscal year ended June 30, 1919, it was pointed out that the purposes of the proposed amendments in section 4433 are first, to do away with the obsolete rule contained in the present law, which prescribes a working steam pressure for single-riveted joints, without taking into consideration the percentage of strength of the riveted joint, and allows 20 per cent additional pressure for double-riveted joints, but which does not allow a greater working pressure for triple-riveted and quadruple-riveted, etc., lap and butt joints, for which greater working pressure should be allowed on account of the greater strength of the tripple-riveted and other joints of greater strength than the double-riveted joints. Boiler users have for many years desired this greater allowable working pressure for the stronger forms of riveted joints, and that desire is perfectly reasonable and should be met by the Government in the interest of better practice, all of which will result to the good and to the advantage of the American merchant marine. The present law does not give an incentive for the building of boilers with stronger joints that will carry a greater working pressure with but slight increase in the amount of material that will be required for double-riveted joints.

*Extracts of an address delivered before the annual meeting of the Society of Naval Architects and Marine Engineers in New York City.

Superpower Stations and Transmission System for Central Indiana

Presenting a paper on "Superpower Stations and Transmission System for Central Indiana," before the Indiana Engineering Society, on Jan. 28, Frederick L. Ray stated that his interest in the subject and determination to take up the investigation was largely due to the influence and writings of John A. Stevens, of Lowell, Mass. As at present laid out, the project is primarily one caring for the power supply of central Indiana, but capable of extension to cover practically all of Indiana and part of Illinois. Mr. Ray recommends locating the necessary power plants in the Wabash River basin and gives figures to prove that a series of power stations of 150,000 kw. capacity each could economically be so located. Table I shows the approximate kilowatt-hours generated, coal consumed and coal per kilowatt-hour for twenty-five cities of central Indiana. According to data presented, covering the cost of current generation and its consumption, it is computed that the annual saving of the plan under consideration would be



MAP SHOWING PROPOSED SUPERPOWER SYSTEM FOR INDIANA

Shaded portion represents developed coal fields. Irregular shaded line shows eastern boundary of coal fields.

approximately 600,000 tons. Table II gives data as to the coal available in Indiana in locations adjacent to the proposed power houses.

At the start Mr. Ray advocates the location of two independent plants of 150,000 kw. each, one at Terre Haute in Vigo County and the other south of Terre Haute in Sullivan County, so connected electrically that each could help the other in case of necessity. Both plants so located on the Wabash River would represent the maximum of economy in electric-current production. Mr. Ray recommends a unit size for boilers of 25,000 sq.ft. of heating surface, three of these operating at 200 per cent rating being capable of furnishing steam for one unit of 35,000 kw. capacity; steam to be generated at 250 lb. per sq.in., with a superheat of 200 deg., giving a total temperature of 605 deg. F., each boiler to be equipped with all-steel superheaters and mechanical soot blowers and enough all-steel economizers to be installed with each boiler to raise the feed-water temperature to a point within 25 deg. F. of the temperature due to the steam pressure. Mr. Ray recommends the use of an underfeed stoker and pulverized-fuel equipment combined, thereby getting excellent efficiency and allowing operation of the boilers at 400 per cent of rating without crowding stokers or coal-pulverizing equipment.

TABLE I. KILOWATT-HOURS GENERATED AND COAL CONSUMED IN TWENTY-FIVE CITIES OF CENTRAL INDIANA

Town	Output in Kilowatt-Hours	Coal Consumed, Tons	Coal per Kilowatt-Hour
Indianapolis	15,191,052	28,780	3.77
Terre Haute and Brazil	3,710,950	7,792	4.19
Crawfordsville	680,660	2,318	6.81
Ft. Wayne	4,767,569	9,516	3.99
Peru and Wabash	555,293	2,266	8.16
Loganasport	692,362	2,519	7.27
Marion and Kokom	2,280,400	6,656	5.83
Richmond	1,289,200	3,068	4.76
Anderson	4,493,100	8,801	3.92
Huntington and Bluffton	795,920	2,510	6.31
Vincennes and Sullivan	2,321,526	3,721	3.20
New Castle and Muncie	5,289,960	8,512	3.21
Columbus	130,510	479	7.34
Lafayette and Frankfort	1,465,233	7,081	9.66
Rushville and Greensburg	52,000	500	...
Martinsville and Greencastle	308,790	915	5.92
	44,024,523	95,434	

Turbines are to be of 60 cycles three-phase 13,200 volts, 35,000-kw. units, 100 per cent power factor. Current generated at 13,200 volts would be transformed to 110,000 volts by step-up transformers for high-voltage transmission and again reduced to 6,600 or any convenient voltage required at various distributing points. The accompanying map indicates the double-ring system of high-voltage transmission lines with cross-connection between the plants. The project being one of coal conservation and in the interest of all the people, the preliminary work of survey and investigation should be carried on in accordance with a plan arranged by a commission appointed for the purpose. Mr. Ray estimates the coal-car requirement for the system as 308 on a basis of six working days, urges electrification of the railroads in this district as soon as possible, but not until other industries have been fully provided for, and emphasizes the fact that there would be nothing experimental in such a system, as it would consist of units of a type already designed or actually in operation.

TABLE II. AVAILABLE COAL RESOURCES

County	Estimated Total Tonnage of Workable Coal Left according to Report of 1908	Total mined since 1908 to 1920 Inclusive, Estimated from Report of Year 1919 of Indiana Industrial Board, 13 Years	Estimated Total Tonnage of Workable Coal Left Jan 1, 1921, Based on Estimated Amount Mined Since 1908
Park	425,000,000	1,300,000	423,700,000
Vermillion	600,000,000	39,000,000	561,000,000
Vigo	1,500,000,000	78,000,000	1,422,000,000
Sullivan	4,000,000,000	39,000,000	3,961,000,000
	6,525,000,000		6,367,700,000

Chicago Mechanical Engineers Discuss Labor

The Chicago section of the American Society of Mechanical Engineers met at the Hotel Sherman on Jan. 25 to discuss the topic "Labor," on which Fred J. Miller, past president of the Society, gave a masterly address.

It was his contention that labor should be handled on a business basis and that much of the welfare work, not any too popular at the best, should be eliminated. Neither employer nor labor should attempt to take advantage when either one or the other had the opportunity. They should co-operate, deal fairly and advance a common interest. It would be found that labor was just as fair as the employer or anyone else, and there should be no tendency in the present dull times toward a resumption by the employer of the arbitrary methods of old.

L. P. Alford took "Efficiency" as his topic and revealed the great waste that is prevalent in machines not working up to capacity.

Labor's Standpoint on the Calder Bill

The interest of the public in a consideration of the coal problem is paramount to all other interests, and labor, as an integral part of the public, is therefore entitled to the fullest possible justice in the final solution of the problem. This is the thought stressed by William Green, secretary of the United Mine Workers of America, in his testimony before the Senate committee considering the Calder Bill.

Mr. Green is very active at the present time in an effort to head off the anti-strike clauses that are being proposed for this bill. He presented three fundamental principles, without due recognition of which he declared there can be no hope of permanent peace and prosperity in the coal industry either under private or public control and no promise that the paramount public interest in the situation will be served. These are the principles: First, the right of collective bargaining on the basis of union recognition; second, the right of labor to a living wage, with differentials for experience, skill and hazards of employment; third, the eight-hour-work day.

Mr. Green took the position that not only is labor entitled to consideration on ethical grounds, but also expediency demands a program that will content the workingman. He pointed out that men cannot be forced to work in this country for wages and under conditions that are unsatisfactory to them, and that even if they could, they would not work efficiently or steadily. He pointed out also that the public interest requires uninterrupted and efficient operation of the coal industry, so that the supply of coal may be dependable in quantity and fair in price. By this train of thought he arrived at the proposition that the men who work in the mines must be reasonably contented and satisfied with conditions and wages, or else any system of government ownership, operation or regulation that may be devised will fail in its purpose.

Mr. Green declared further that whatever the rights of labor may be, to deny or abridge any of them is exactly as unjust and unsound as a matter of public policy as it would be to confiscate the property of capital without fair compensation. He said without hesitation that the rights of labor are superior to the rights of capital.

While he carried his conclusions, perhaps, a little too far, this very able representative of organized labor is bringing out some points that are deserving of careful consideration in connection with the Calder bill and the general subject of regulation of the coal industry. Certainly, labor troubles in the past have played no small part in upsetting the coal business, and it is safe to assume that their solution now would make much easier a settlement of the whole problem.

Heating and Ventilating Engineers Hold Annual Meeting

The twenty-seventh annual meeting of the American Society of Heating and Ventilating Engineers was held in New York and Philadelphia, Jan. 25 to 28, 1921. The opening, or business, session was held in accordance with the by-laws of the organization on Tuesday forenoon, Jan. 25, at the Engineering Societies Building in New York. The usual routine reports were presented and the following officers elected for the coming year: President, Champlain L. Riley; first vice president, Jay R. McColl; second vice president, H. B. Gant; treasurer, Homer Addams.

The next, or opening professional, session was held at the Bellevue-Stratford Hotel, Philadelphia, on the forenoon of Jan. 26. This was followed in the afternoon by a trip to the League Island Navy Yard, where many of the members were given an opportunity to revise their opinions as to the present activities of the United States in the construction of airplanes. Forenoon and afternoon sessions were held during the succeeding days of the meeting, all with very satisfactory attendance. Abstracts of the following papers of interest to *Power* readers are being published in current issues: "Steel Smokestacks," by W. E. Goldsworthy; "Radial Brick Chimneys," by W. F. Leggo; "Pulverized Coal for Power Plants," by Frederick A. Scheffler, and "Economizers," by W. F. Wurster.

Adequate arrangements were made for visits on the part of members and ladies to points of local interest, and on Thursday evening, the annual banquet of the society was held in the ballroom of the Bellevue-Stratford, followed by dancing. Joseph A. Steinmetz made a most acceptable toastmaster, and the speakers of the evening were the Hon. William C. Sproul, Governor of Pennsylvania, Hon. J. Hampton Moore, Mayor of Philadelphia, and the Hon. Huston Thompson, chairman of the Federal Trade Commission. The cuisine was up to Clover Club standard, the addresses were timely and interspersed with enthusiastic and felicitous references to plans now being made for the forthcoming 1926 Philadelphia Exposition, and the music, both instrumental and vocal, was satisfactory. The meeting was well attended throughout and a success in every way.

American Engineering Council To Meet

American Engineering Council, the governing board of the Federated American Engineering Societies, will hold its second meeting on Feb. 14 in Syracuse. A feature of the meeting will be an address in the evening by Mr. Hoover, president of the Federation, who is expected to outline the new Council's plans for the future. Delegations and representatives from many cities will gather at Syracuse for this meeting, and for a meeting of the council of the American Society of Mechanical Engineers, which will be held in the same city on Feb. 15, with Edwin F. Carman, the new president, in charge.

The American Institute of Electrical Engineers will be represented on American Engineering Council by Calvert Townley, of the Westinghouse Electric and Manufacturing Co.; the American Institute of Mining and Metallurgical Engineers by J. Parke Channing, of New York; the American Society of Mechanical Engineers by Dean Dexter S. Kimball of Cornell University, and the Associated Engineers' Society of St. Louis by William E. Rolfe. These four representatives are all vice-presidents of the Federation.

The coming meeting is an important one, for many plans of the Council will take definite form. One question which will be discussed and which has attracted a good deal of attention is the organization of engineers on a territorial basis. It has been suggested that councils of engineers be formed in every state as sections of the Federation.

Engineers and Economists To Co-operate

The problems of production, labor, waste, industrial morale and efficiency, together with their underlying economic considerations, are to be discussed in a series of monthly conferences arranged by the New School for Social Research. The first conference is to be held Feb. 9 at 8 o'clock. The meeting place will be the auditorium of the New School at 469 West Twenty-third St., New York City. It is planned to make the meetings open forums in which engineers and economists can meet and talk over problems that are beyond the field of either and which can therefore best be considered mutually.

At the first conference Dr. Harlow S. Person, of the Taylor Society, Dr. Leo Wolman, Lawrence Frank and O. S. Beyer, Jr., of the New School, will each dwell on a special phase of the subject "Production and the Engineer" preparatory to throwing the conference open for general discussion. There will be no charges or tuition fees of any kind.

Bisbee Chapter of the American Association of Engineers, at a recent meeting, passed a resolution to the effect that it would do all in its power to secure passage of an engineers' license law for Arizona at the next session of the state legislature. M. G. Adler was elected president, and H. A. Lund was chosen as publicity manager.

The United States Bureau of Foreign and Domestic Commerce has on file at its central and district offices a number of consular reports on electric current and central power stations in foreign countries.

Washington News

U. S. Engineers Recommend Great Falls Development—Hearing on Great Falls Project—Further Hearings on Calder Bill—Additional Water Power Applications

By Paul Wooton
Washington Correspondent

Development of the water power at Great Falls on the Potomac is recommended in a report that was sent to Congress Jan. 29 by Major Max Tyler, Corps of Engineers, U. S A. The report was approved by the Chief of Engineers and by the Board of Engineers for Rivers and Harbors. It was prepared at the request of the Federal Power Commission, which was instructed in the Water Power Act to have the investigation made.

The report calls for the construction of two dams, three supply reservoirs, a new filtration plant, and a new conduit from Great Falls to the City of Washington. The power development, it is estimated, will cost $44,421,000. An additional $9,523,000 will be required, it is estimated, to provide for an additional water supply. The report does not cover the matter of power distribution.

Simultaneously with the release of the engineers' report the United States Geological Survey makes public its report on the physical data involved. The Geological Survey report does not attempt to go into the economic features of the problem.

The engineers' report points out that Great Falls can be harnessed economically for power purposes only when the maximum contemplated is marketable. Any effort to develop the falls for the purpose of supplying power to the Government only would not be feasible, it is stated. The report recommends the construction first of a dam at Chain Bridge. That development would produce annually 364,000,000 kw.-hr. This power could be delivered to the substation in Washington at a cost of 7 mills, it is stated. That figure is two mills under the present cost of developing power at the large steam plant of the Potomac Electric Power Co. Consumption of electricity in the District of Columbia now is at the rate of 308,000,000 kw.-hr. annually. Thus the Chain Bridge development alone could supply the existing needs, with a small margin to spare. By constructing a second dam at Great Falls, the output, the report asserts, could be increased to 675,000,000 kw.-hr. With the two dams the cost at the main substation in Washington would be 6.75 mills, it is estimated.

No economy would be effected, the report says, by combining the water-power development with the water-supply development. This is of particular importance, owing to the urgent need of supplying additional water to Washington at a time earlier than the development of the power project probably would be undertaken.

The purpose of the Geological Survey's report is to show the probable extent of availability of the yield of the Potomac River basin. It shows that during the twenty-three years for which records are available, the Potomac River at Great Falls has had an average flow of 11,900 sec.-ft., a maximum flow of 248,000 sec.-ft. and a minimum of 653 sec.-ft. The flow was less than 3,000 sec.-ft. for 20 per cent of the time, and during 1914 it averaged only 1,780 sec.-ft. for a period of 120 consecutive days. The report shows that there are in the Potomac basin fourteen reservoir sites that apparently are suitable for economic development. These sites would store 3,400,000 acre-feet, or more than 40 per cent of the average annual run-off from the basin.

On the basis of theoretical operation during the twenty-three years, four reservoirs having a total capacity of 1,400,000 acre-feet could have been operated so as to have maintained a monthly flow at Great Falls of not less than 6,000 sec.-ft., without storage. This increase of 4,000 sec.-ft. in the minimum flow, if used in a modern hydro-electric plant, operating with a head of 160 ft. at 75 per cent efficiency, would yield as much energy as 356,000 tons of coal per annum, burned in an efficient steam power plant consuming only two pounds of coal per kilowatt-hour of generated power.

Hearing on Great Falls Project

Little opposition to the Tyler report developed at the hearing conducted by the Federal Power Commission on Feb. 1. The fact that the important interests concerned interposed no objections and showed no tendency to challenge any phase of the report is regarded as significant. Another development at the hearing was the emphasis given the advisability of treating the water supply of the District of Columbia as a separate project.

The Secretary of War, in opening the hearing, made a plea for the early development of the power at Great Falls as well as at every other available site in the country. He expressed the opinion that the demand for power in the District of Columbia and the adjacent areas of Virginia and Maryland is so great that there is no likelihood of putting a large steam plant in Washington out of business.

J. H. Leavering, an independent engineer, representing no special interest, suggested that the Chain Bridge dam could be made 150 feet high and would result in important economies. He has a plan for development which would cost less money, he says, and would insure the delivery of power in Washington at three mills per kilowatt-hour.

Col. Charles W. Kutz, the engineer commissioner of the District of Columbia, stated that the District Commissioners believe the report is entirely reasonable and capable of effective accomplishment. He pointed out the desirability, however, of keeping separate the Federal project of developing the power and the District problem of obtaining a water supply.

William F. Ham, president of the Potomac Electric Power Co., inquired of the commission if the Great Falls project is a part of the superpower plan that is recommended by the United States Geological Survey. He urged that all possible notice be given of the Government's plans, so that his company would not expand wastefully the large steam plant which it operates in Washington.

Amendments Likely in Coal Bill

Hearings on the Calder coal bill continued much longer than was contemplated originally. The complexity of the problem was so impressed on the committee that the plan to limit the hearings to three days was abandoned. At this writing it seems probable that the bill will be reported favorably to the Senate within the next few days. It is admitted that the bill will be amended in important particulars. Senator Calder himself has asked that it be amended so as to apply to all coal dealers. The bill as introduced exempts dealers whose gross annual sales are less than $500,000.

With the extension of the hearings the possibilities of passing the legislation at this session of Congress has grown materially less. The bill is certain to provoke extended discussion. The legislative program already is in a state of congestion. Any bill likely to meet with prolonged opposition would find little favor with the Senate leaders. It is generally admitted, however, that the hearings have brought out many matters of great value and most certainly have brought home to coal operators and dealers that there is a possibility of Federal regulation of the coal industry.

Additional Water Power Applications

Among the applications for water-power permits received during the week ending Jan. 29 may be mentioned: The Lockport Paper Co., requesting a diversion of 500 cu.ft. sec. through the State Barge Canal to Lockport, N. Y.; The Houston Power Co., for a dam and power house on the Choctawhatchee River at Hollis Bridge; The Utah Power and Light Co., for a dam, tunnel and power house on the Green River; The McConnellsville-Malta Electric Co. for a power house on the Muskingum River at Malta, Ohio; C. I. Kephart for a dam and diverting ditch to power house at Cougar on the Lewis River, Wash., and another on the Toutle River in Wash.; also an application from Lincoln Waln and W. T. Young for a development at Power Creek near Cordova, Alaska; and one from J. F. Myser and E. F. Drach for a series of mine diversion dams leading to five power houses on the Frying Pan River in Colorado.

New Publications

CONNECTING INDUCTION MOTORS. By A. M. Dudley. Published by McGraw-Hill Book Co., Inc., New York, 1921. Cloth; 6 x 9 in.; 252 pages; 289 illustrations; 10 tables. Price, $2.50.

There have been published a number of highly technical books on the induction motor, but it remained for this volume to tell the practical story. In the author of this book we have a rare combination of easy style of presenting the subject, long experience (15 years designing induction motors) with the equipment he is discussing and a deep appreciation of the practical man's problems in dealing with the induction motor. The book contains the series of articles on "Reconnecting Induction Motors," published in *Power*, along with a number of articles appearing in the *Electric Journal*.

The subject of reconnecting induction motors is treated in such a way that a winding may be, where possible, reconnected by a change in frequency, number of poles, speed, phase and volts, and after the change is worked out a method is given whereby it can be determined how the winding will act under the changed conditions. Examples are worked out to show how to apply the methods given throughout the work. In Chapter XIII are given 80 diagrams of two- and three- phase windings for two- to fourteen-pole motors, and in Chapter XIV are given diagrams of typical wave winding for four to twenty-four pole rotors. A large proportion of the illustrations throughout the work are induction-motor winding diagrams. The method that has been employed for showing a developed winding makes it easy for the reader to picture the actual winding in the machine. Table V shows how a winding may be changed for any combination of phase and voltage. From this table can be determined in a few seconds what would otherwise require considerable time if calculations were resorted to. In Chapter XI 30 pages are devoted to locating faults in induction-motor windings and this is the most comprehensive treatment ever published on this subject. How to figure a new winding for an old core is the subject treated in Chapter XII. An induction motor without a winding is taken and the problem of calculating a new winding for it is worked out.

Wherever calculations have been resorted to the problem has been solved by simple arithmetic, so that those with a limited technical training can apply the methods given to their problems. Not only will the practical men find in this book a wealth of information, but the student will also find a practical presentation of many questions arising in winding and connecting alternating-current motors.

A method of checking winding connections is given that reduces this problem to the equivalent of tracing a simple circuit.

STRUCTURE IN PALEOZOIC BITUMINOUS COALS. By Reinhardt Thiessen. Published by the Government Printing Office, Washington, D. C. Paper; 6 x 9 in; 310 pages; 140 plates. Obtainable on application to the Superintendent of Documents, Government Printing Office, Washington, D. C

This is Bulletin No. 117 of the Bureau of Mines, Department of the Interior. The author states that the aim of the paper is to fill in a few of the gaps and to clarify some of the existing confusions in the deductions as to the origin and formation of coal, based upon its microscopical study, and that the immediate cause of his investigation was that when an attempt was made to discover the meaning of the coking and non-coking properties of coal a more exact knowledge of its nature was required than he found available. The coals forming the basis of the study were selected from nearly a score of mines in various parts of the country, and comparisons are made with coal from China, Japan, New South Wales and England. In the introduction several pages are devoted to a historical review of the work accomplished by previous investigators, followed by a description of the methods adopted in the selection of specimens and the preparation of sections for microscope. The origin and qualities of peat are treated at length, the main body of the text, however, being devoted to "structure in coal" as illustrated in the plates, which in almost every case show two or more specimens, making a total of something over 300 illustrations. There is a copious index, and the book is sufficiently non-technical in character to be of interest to the general public so far as it is concerned in the scientific aspect of present fuel conditions.

PROPERTIES OF STEAM AND THERMODYNAMIC THEORY OF TURBINES. By H. L. Callender, M.A., Etc., Professor of Physics in the Imperial College of Science and Technology London. Published by Longmans, Green & Co., New York. Size, 6 x 9 in.; 520 pages; 36 illustrations, steam tables, etc. Price, $14.

The author of this work on the properties of steam has devoted a greater part of his life to experimental work with steam, and he has herein embodied the results of his labor as well as the experiments of various other investigators. In the first part of the book is given a record of the investigations undertaken and results obtained by all notable physicists. The discussion is essentially one concerning the thermodynamical aspect of steam and should be welcomed by all engineers whose work requires calculations involving the properties of steam. A considerable portion is given up to the thermodynamics of the turbine, both repulsion and reaction types. The author also presents his steam chart, which he terms the *H log P* diagrams. This is not so well known as the Mollier, but is of more advantage when dealing with very low pressures, since the scale readings are more accurate, depending on the pressure ratios rather than on the pressure value.

REPORTS OF OIL INVESTIGATIONS

A 57-page report on "Properties of Typical Crude Oils from the Eastern Producing Field of the United States," by E. W. Dean, petroleum chemist, Bureau of Mines. The report is preliminary only, but contains a quantity of such figures as are available at the present time from the survey which the Bureau of Mines is conducting in the Eastern oil fields.

PREVENTION OF COAL MINE FIRES

Miners' Circular 27, prepared by Edward Steidle for the Bureau of Mines, entitled "Causes and Prevention of Fires and Explosions in Bituminous Coal Mines." Mainly photographs, contrasting safe and dangerous practice in mining. Copies may be obtained at a nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C.

DETECTING LEAKAGE OF GAS

Technical Paper 267, prepared by S. H. Katz and V. C. Allison for the Bureau of Mines, describing the use of stenches for detecting leakage of blue water gas and natural gas. Copies may be obtained at a nominal cost from the Superintendent of Documents, Government Printing Office, Washington, D. C.

THE FEDERAL WATER-POWER ACT

A pamphlet containing a history of water-power legislation, a topical synopsis of the Federal Water-Power Act and a full copy of the act, prepared by Black, McKenney and Stewart, Engineers, 618 Seventeenth St., N. W., Washington, D. C.

Personals

Henry R. King is now general sales manager of th M. S. Wright Co. He specialized on power apparatus for 22 years with the Western Electric Co.

John W. Armitage, previously chief engineer of a Philadelphia school, has taken a position as erecting engineer for the Automatic Fuel Saving Co., Philadelphia.

Julian Loebenstein, formerly with Viele, Blackwell & Buck, has taken the position of chief engineer of the Hopewell Insulation and Manufacturing Company, Inc., Hopewell, Va.

Dave Larkin, formerly engineer in the Fifth Avenue Building, New York, is now head of the firm of Larkin & Pratt, consulting engineers, Arcade Building, St. Louis, Mo.

Society Affairs

Los Angeles Section, A. S. M. E. will meet Feb. 11, to hear E. S. Carmen speak on "The Engineer and His Opportunity."

The Engineers' Club of Philadelphia will meet Feb. 15 to hear P. H. Gadsden, vice-president of the United Gas Improvement Co., discuss "Public Utility Problems."

Cleveland Section, Association of Iron and Steel Electrical Engineers, will meet on Feb. 14 to hear a talk by M. C. Benjamin, of the Benjamin Engineering Co., on "Scientific Combustion Control for Boiler Furnaces."

The Buffalo Section, A. S. M. E., will hold a meeting on Feb. 15, at 8 o'clock at the University Club. A. M. Candy, of the Westinghouse Electric & Manufacturing Co., will speak on the subject of "Modern Practice in Arc Welding."

Pittsburgh Section, Association of Iron and Steel Electrical Engineers, will meet Feb. 19 to hear B. G. Fernald, a New York City consulting engineer, speak on "Reliability of Steam and Electrical Applications in the Iron and Steel Industries."

Birmingham Section, Association of Iron and Steel Electrical Engineers, will hold a meeting on Feb. 19 at which H. T. White, chief electrician of the Chickasaw Ship Building Co., will discuss "Electrical Features of the Chickasaw Ship Building Plant."

Business Items

The C. H. Wheeler Manufacturing Co., of Philadelphia, has opened a branch sales office in the Leader News Bldg., Cleveland, Ohio, which will be in charge of W. J. Eicher.

The Frederic H. Mason Co. has been formed by Frederic H. Mason, P. F. W. Tim and Ray C. Coberly. The firm represents a number of power-plant apparatus manufacturers in the Detroit territory.

The Jarvis Engineering Co., engineer and contractor for power-plant equipment and installations, refrigerating plants and incinerators, has moved into its new factory and office building at 51 Ellery St., South Boston.

Edward R. Ladew Co., Inc., of New York City, tanner and leather belt manufacturer since 1835, has closed its sales office at Charlotte, N. C., and transferred its Southern headquarters to 95 South Forsyth St., Atlanta, Ga.

The Atlas Valve Co., Newark, N. J., has purchased from the Ideal Automatic Manufacturing Co. sole patents and manufacturing rights of the "Ideal" Automatic Pump Governor, a device for regulating the pressure of steam, air or water.

The Conveyors Corporation of America has appointed E. D. Kellogg New Jersey representative for its line of machinery for handling coal, sand, gravel, ashes and other loose, bulky materials. He will make his headquarters at 110 West 40th St., New York City.

The Hooven, Owens, Rentschler Co., Hamilton, Ohio, has appointed the John Fenson Co., Richmond, Va., as its Virginia representative. The Sunderland Machinery and Supply Co., Omaha, Neb., Omaha district representative, and Walter T. Paine the representative in the Boston district.

Trade Catalogs

The Stanley Belting Corp., 44 South Clinton St., Chicago has issued a 5 x 7 in. 14-page catalog of Stanley solid woven bearing.

The Metal & Thermit Corp., New York City, is sending out a little 41-page booklet of instructions on the use of Thermit welding in railroad shops.

The Allis-Chalmers Manufacturing Co., Milwaukee, Wis., has just put on the market a small single-phase repulsion motor, which is described in the company's bulletin No. 1113.

The Northern Engineering Works, Detroit, Mich., are distributing their condensed general catalog No. 28, 6 x 9-in. 32-page booklet describing electric traveling cranes and miscellaneous hoisting equipment.

Coppus Engineering and Equipment Co., Worcester, Mass., has just received from the printer a new 5½ x 9 in., 50-page catalog describing in great detail the Coppus turbo blower for undergrate draft and other industrial purposes. The book covers its subject in a thorough and interesting way.

Edward R. Ladew Co., Inc., New York City, has just issued two very attractive booklets, one 32 and the other 80 pages long. One, called the "Proof Book," contains interesting pictures and descriptions of Hoyt belting installations, and the other is a catalog that covers very thoroughly the manufacture of these belts.

FUEL PRICES

FUEL PRICES
Bituminous

The following table shows the trend of the spot steam market in various coals (mine-run basis, f.o.b. mines):

Coal	Market Quoted	Govt. Price	Dec. 27, 1920	Jan. 24, 1921	Feb. 1, 1921
Pocahontas	Columbus	$2.35	$5.63	$4.00	$3.75
Clearfield,	Boston.....	2.95	3.75	2.85	2.75
Somerset,	Boston.....	2.95	4.50	3.65	3.55
Pittsburgh,	Pittsburgh..	2.35	2.75	2.50	2.50
Kanawha,	Columbus...	2.70	2.90	2.90	2.35
Hocking,	Columbus...	2.50	2.50	2.50	2.40
Pittsburgh 8,	Cleveland...	2.35	3.00	2.60	2.50
Franklin, Ill.,	Chicago....	2.35	3.40	2.75	2.75
Central, Ill.,	Chicago....	2.35	2.50	2.25	2.15
Ind. 4th vein,	Chicago....	2.35	3.25	2.50	2.15
Standard,	St. Louis....	2.55	....	2.50	2.35
West Ky.,	Louisville...	2.35	2.75	2.35	2.50
Big Steam,	Birmingham	2.45	3.25	3.25	3.00
S. E. Ky.,	Louisville...	3.00	3.40	2.70	2.70

DIESEL FUEL OIL

Chicago—24@28 deg. Baumé, $1.10@$1.20 per bbl.; 32@34 deg., 3¼@4¼ c. per gal.

Cincinnati—In 8,000-gal. tank cars: 26@28 deg., 9¾ c. per gal., 30@34 deg., 10c.

Cleveland—24@30 deg. fuel oil, group 3, $1.25 per bbl.; gas oil, group 3, 4½c. per gal. No market for boiler oil.

Philadelphia—26@28 deg. fuel oil, 8½c. per gal.; 30@34 deg. gas oil, 10½c.; 16@20 deg. boiler oil, 6½c.

St. Louis—Base plus freight; group 3: 24@26 deg., $1.10@$1.25 per bbl.; 26@28 deg., $1.20@$1.35;, 28@30 deg., $1,30@$1.45; 30@32 deg.,$1.40@$1.55; 32@34 deg., $1.50@$1.65. No market for 16@20 deg. Baumé boiler oil.

New Construction

PROPOSED WORK

N. H., Lanconia—The School Bldg. Comn. is having plans prepared for a 3 story high school. About $250,000. Architect not announced.

Mass., Palmer—The Memorial High School Comm. will receive bids until Feb. 14 for a 3 story high school including a steam heating system on Converse St. About $300,000. E. C. & G. C. Gardner, 33 Lyman St., Springfield, Archts. Noted Jan. 25.

Mass., Stoughton — The School Bldg. Comn. plans to build a 3 story high school. About $250,000. Peare, Quiner, Nevin & Chickering, 8 Beacon St., Boston, Archts.

Mass., Worcester — The New Co., 340 Main St., plans to build a 6 story, 170 x 170 ft. apartment building. About $800,000. J. D. Leland, 41 Mt. Vernon St., Boston, Archt.

Mass., Worcester—The Holy Cross College, Rev. J. J. Carlin, Pres., is having plans prepared for a 4 story, 110 x 110 ft. dormitory building. About $300,000. Maguinnis & Walsh, 100 Boylston St., Boston, Archts.

R. I., Scituate (North Scituate P. O.)—The Water Supply Comrs., City Hall, Providence, are having plans prepared for a main dam and dyke here. Est. cost, between $3,000,000 and $4,000,000. F. E. Winsor, c/o above address, Chief Engr.

Conn., Hartford — The Bd. of Water Comrs. is having plans prepared for a hydro-electric plant and the installation of equipment in connection with new filtration plant in West Hartford. C. M. Saville, 1026 Main St., Hartford, Chief Engr.

Conn., Storrs (Eagleville P. O.)—The Bd. of Trustees of the Conn. Agricultural College plans to purchase new equipment for refrigerator plant. About $6,000.

N. Y., Auburn—F. Alexander, 6 Seminary Ave., is in the market for one No. 125 to No. 200 stationary air compressor with tank and motor.

N. Y., Baldwinsville—The James Frazee Milling Corp. is in the market for small motors up to 50 kva. R. H. Quackenbush, Pres.

N. Y., McKeever—The Iroquois Paper Co. plans to rebuild the power dam across Moose River, here. About $100,000.

N. Y., Medina—The Western New York Utilities Co. will have preliminary survey made for a third power dam at Oak Orchard-on-Ridge, 3 miles northeast of here.

N. Y., New York—Dept. of Docks, Pier A, North River, will receive bids until February 10 for furnishing and installing freight-handling equipment on pier at the foot of East 5th St., East River.

N. Y., New York—People's Hospital, Adeberg & Berhman, Chn., 311 6th Ave., is having sketches prepared for hospital including a steam heating system on 16th St. and 1st Ave. About $1,000,000. Ludlow & Peabody, 101 Park Ave., Archts. and Engrs.

N. Y., Ogdensburg — The Ogdensburg Paper Mills, Inc., is in the market for small motors up to 75 kva. J. A. Outterson, Pres.

N. Y., Watertown—The Bd. Educ., F. S. Tisdale, plans to install a new heating and ventilating system in the Watertown High School. About $10,000.

N. J., Glen Moore — The Delaware River Quarry & Constr. Co., R. A. Montgomery, Pres., 21 Bridge St., Lambertville, plans to build a boiler house and a quarry building here. About $100,000.

N. J., Park Ridge—E. Sibley, Archt., Palisade, has completed plans for a high school on Park Ave. and Main St., here. About $265,000.

Pa., Harrisburg—The Amer. Cold Storage Co. plans to build a 7 story cold storage plant on South 2nd St. C. E. Schaup & Co., 222 Market St., Engrs.

Pa., Scranton—County of Lackawanna is having plans prepared for interior alterations including a new steam heating system in the court house here. About $200,000. F. A. Nelson, Connell Bldg., Archt.

Md., Baltimore—The Wizard Check Endorser & Printing Mach. Co., Inc., Calvert Bldg., will soon award the contract for first unit of a 102 x 384 ft. plant. Deep well pumps, motors, etc., will be required. F. A. Fletcher, Charles St., Archt.

Del., Lewes—The Bd. Educ. plans to build a 2 story, 100 x 200 ft. school on South St. About $250,000. Guilbert & Betelli, 2 Lombardi St., Newark, N. J., Archts.

W. Va., Shinnston—The Roberts Eng. Co., Engrs., Charleston, will receive bids until February 17 for a municipal filter plant and pump house.

N. C., Dunn—Harnett County proposes to expend $100,000 for rebuilding the power, light and water plant here.

Ala., Mobile—G. B. Rogers, Van Antwerp Bldg. and C. L. Hutchisson, Emanuel Bldg., Associate Archts., have been selected to prepare plans for a new Masonic Home on St. Francis St. About $400,000.

La., New Orleans—The Masonic Grand Lodge of Louisiana, Masonic Temple, St. Charles and Perdido Sts., had plans prepared for a 19 story, 100 x 170 ft. office and fraternal building. About $3,000,000. S. Stone, Jr., 714 Union St., Archt.

La., Shreveport—L. I. Kahn, Comr. of the Dept. Pub. Utilities, will receive bids until February 24 for a pumping station and appurtenances. J. N. Chester Co., Union Bank Bldg., Pittsburgh, Pa., Engrs. Noted Feb. 1.

O., Canton—F. L. Cole, 205 City Natl. Bank Bldg., leased a site at Tuscarawas St. and Cleveland Ave. and plans to build an 8 story, 67 x 200 ft. office building. About $600,000.

O., Cleveland—The Brotherhood of R.R. Trainmen, A. E. King, Secy., Ullmer Bldg., is having plans prepared for an 8 story, 50 x 100 ft. office building including a steam heating system. About $750,000. C. S. Schneider, 2258 Euclid Ave., Archt.

O., Cleveland—The Erney Realty Co., c/o F. C. Erney, 1254 Euclid Ave., leased a site at East 8th St. and Prospect Ave. for a 7 story, 57 x 208 ft. addition to an office building. About $250,000. A. E. Sprackling, Caxton Bldg., Archt.

O., Cleveland—B. F. Keith Theatre Co., 1564 Bway., New York City, plans to build a 16 story theater and office building on Prospect Ave., here. About $2,500,000. Rapp & Rapp, 190 North State St., Chicago, Ill., Archts.

O., Cleveland—The Bd. Educ., East 6th and Rockwell Ave., plans to install heating boilers in Bolton, Woodland, Fairmount, East Madison and Lawn Schools.

O., Middletown — The Memorial Bldg. Comn., D. E. Smith, Secy., is having plans prepared for a 3 story memorial building at 2nd St. and Bway. About $300,000. T. Scott, Archt.

O., Springfield — The Boston Store Co., C. E. Dahlgren, Mgr., 42-50 South Limestone St., will soon award the contract for a 5 story, 70 x 130 ft. store and office building including a steam heating system on South Limestone St. About $300,000. Hall & Lethly, 806 Fairbanks St., Archts.

Mich., Detroit — The Police Dept., J. Inches, Comr., Bates and Farmer Sts., plans to build a 6 story police headquarters building including a steam heating system. About $1,500,000. A. Kahn, 1000 Marquette Bldg., Archt.

Mich., Hamtramck (Detroit P. O.)—The Palmer Bee Co., Cameron Ave. and East Grand Blvd., plans to build a 4 story factory for the manufacture of conveying equipment, at Dequindre St. and Poland Ave. About $800,000.

Ill., Chicago—The Y. M. C. A., Hyde Park, plans to build a Y. M. C. A. building. About $400,000.

Ill., East St. Louis—The Beall Pressed Steel Co., 20th and Brady Sts., is in the market for 1 acetylene generator, 50 to 100 lb. capacity.

Wis., Edgerton—G. T. Simmons, R. F. D. No. 8, Janesville, plans to build a 4 story, 70 x 181 ft. spark plug factory, here. Power machinery will be required. About $100,000. The erection of a power house is under consideration. Architect not selected

Wis., Oshkosh—The City Natl. Bank, A. A. Abraham, Cashier, is having plans prepared for a 4 story, 57 x 105 ft. bank and office building including a steam heating system at Main and Waugoo Sts. About $350,000. R. A. Messmer & Bros., 1004 Majestic Bldg., Milwaukee, Archts.

Wis., Stevens Point—The Stevens Point Hotel Co., c/o Chamber of Commerce, plans to build a 5 story, 100 x 100 ft. hotel. About $250,000. A. C. Clas, 445 Milwaukee St., Milwaukee, Archt.

Iowa, Iowa City — The Iowa Memorial Union, W. H. Bates, Secy., had plans prepared for a 3 story, 90 x 90 ft. memorial hall including a steam heating system at the State University. About $350,000. Boyd & Moore, 1018 Locust St., Des Moines, Archts.

Iowa, Troy Mills—The Natural Research Development Co. is having plans prepared for waterworks improvements and power house. About $50,000. Holland, Ackerman & Holland, 122 North 4th St., Ann Arbor, Mich., Engr.

Minn., Bemidji — The Bd. Educ., R. O. Bagley, Supt., plans to build a 2 story, 145 x 270 ft. high school including a steam heating and mechanical ventilating system on Main St. About $400,000. E. F. Broomball, 707 Alworth Bldg., Duluth, Archt. and Engr.

Minn., Chisholm—The Bd. Educ., E. Drew, Clk., plans to build a 2 or 3 story vocational school including a steam heating system. About $450,000. Architect not announced.

Minn., Duluth—W. Wall, 301 Torrey Bldg., is chairman of a committee which is organizing a corporation to build a 7 story, 140 x 300 ft. hotel including a steam heating system. About $1,000,000. Architect not selected.

Minn., Hastings—The State Bd. of Control, D. F. Mullen, Secy., Capitol, St. Paul, will submit to the Legislature, a construction program including a power house and the installation of equipment at the State Asylum for the Insane, here. About $70,000.

Minn., Rush City—J. F. Sommers, City Clk., will receive new bids until February 18 for waterworks system including a pump house and one triplex pump, motor, etc. Former bids rejected. Druar & Milinowski, 512 Globe Bldg., St. Paul, Engrs.

Minn., St. Paul—College of St. Thomas, R. H. Moyihan, Pres., is having plans prepared for several college buildings including a steam heating system at Cleveland and Summit Aves. About $300,000. Maguinnis & Walsh, 100 Boylston St., Boston, Mass., Archt.

Minn., Swift Falls (Benson P. O.)—The city of Benson is considering the development of water power here. About $25,000. L. M. Pedersen, City Clk.; W. E. Skinner, 15 South 5th St., Minneapolis, Engr.

Kan., Osborn—The city plans to build a new power house and install new oil unit. Machinery in present plant will be removed to new plant.

Kan., Pittsburgh—The Bd. of Trustees of the Masonic Temple, c/o E. B. Lanyon, Pres. of the Natl. Bank of Pittsburg, had preliminary plans prepared for a 2 and 3 story temple. About $375,000. W. Schmitt, Oklahoma City, Okla., Archt.

S. D., Elk Point—The city plans an election soon to vote on improving light and power plant. About $20,000. M. R. Hendricks, City Recorder.

S. D., Rapid—The State Senate, Pierre, passed a bill appropriating $2,000,000 for the purchase of a site and building a state cement plant here.

N. D., Jamestown—Jamestown College, B. H. Kroeze, Pres., plans to build 4 college buildings including a steam heating system. About $400,000. Architect not announced.

N. D., Minot—State Normal School, A. G. Crane, Pres., plans to build additions including a steam heating system to the normal school. About $500,000. Architect not announced.

Mo., Joplin—T. Phelps, 628 Main St., will receive bids until February 15 for a 2 story, 35 x 40 ft. coal colliery to cost about $25,000. Coal mine and steam power equipment to cost $5,000 will be installed in same.

Tex., Corsicana — The Corsicana Ice Plant plans to increase its daily capacity to 90 tons. New machinery will be installed. About $75,000.

Tex., Dallas—The First Baptist Church, 606 North Ervay, is having plans prepared for a church including a steam heating system. About $800,000. R. H. Hunt Co., South West Life Bldg., Archts.

Tex., Dallas — The Southern Methodist University is having plans prepared for a memorial building including a steam heating system. About $500,000.

Tex., Fort Worth—The Peden Iron & Steel Co., Main and Daggett Sts., is having plans prepared for a steel roller mill and fabricating plant. Electrically operated machinery will be installed in same. About $1,000,000. D. R. Luce, Engr.

Tex., Ranger—The Humble Oil & Refinery Co., Goggan Bldg., Houston, is having plans prepared for a topping plant here, in connection with its oil refinery. About $500,000.

Tex., Ranger—Chestnut & Smith are having plans prepared for a casinghead gasoline plant. Machinery for reducing gas from wells to liquid gasoline will be installed in same. About $500,000.

Tex., San Antonio—Scottish Rite Masons, St. Mary's and Convent Sts., are having plans prepared for a 3 story, 100 x 150 ft. cathedral including a steam heating system at Ave. E and 4th St. About $700,000. H. M. Greene, North Texas Bldg., Dallas, and R. H. Cameron, San Antonio, Archts.

Okla., Mountain View—The city is having plans prepared for power plant equipment in connection with the pumping station. About $30,000. V. V. Long & Co., Oklahoma City, Engrs.

Okla., Okmulgee—Okmulgee Lodge 199 A. F. and A. M. is receiving bids for a 7 story, 69 x 102 ft. office and lodge building including a steam heating plant. About $400,000. J. M. Whitehead and R. E. Jenness, Rebold Bldg., Archts.

Col., Denver—Consistory No. 2 of the Scottish Rite plans to build a 3 story, 115 x 170 ft. cathedral at 16th and Grant Sts. About $500,000. Parry & Gardner, Guardian Trust Bldg., Archts.

Wash., Tacoma — The Municipal Water Dept., W. A. Kunigk, 403 City Hall, Supt. and Engr. will receive bids until about February 15 for monorail system, bridge cranes and testing appliances for the light and water departments. About $75,000.

Cal., Brawley—T. E. Mulligan and C. V. West, San Diego, are having plans prepared for a 2 and 3 story, 60 x 130 ft. hotel, here. About $250,000. L. L. Jones, 468 P. E. Bldg., Los Angeles, Archt.

Cal., Glendale—The city received bids for an electrically operated pumping plant from J. C. Bannister, 903 North Mariposa St., Los Angeles, $19,186; E. E. East, Glendale, $21,465; T. Haverty Co., 8th and Maple Sts., Los Angeles, $23,740. One centrifugal pump and a 60-hp. motor will be required. H. B. Lynch, 1007 Van Nuys Bldg., Los Angeles, Engr. Noted Jan. 18.

Cal., Long Beach — H. H. Lochridge, Archt., 700 Markwell Bldg., is preparing plans for a 12 story office building at 3rd and Atlantic Sts. About $1,250,000. Owner's name withheld.

Cal., Los Angeles—The Southern California Edison Co., 306 West 3rd St., plans approved for a 6-year construction program including reservoir at Florence Lake, an 11-mile tunnel from Florence to Huntington Lakes, conduit from Huntington to Shaver Lakes, 3 hydro-electric generating stations and enlargement of power house No. 8. This development will give the company an additional capacity of 316,000 kw. About $48,000,000. Engineer not selected.

Cal., Los Angeles—O. Morosco, 752 South Bway., is having plans prepared for the erection of a group of 1 and 2 story amusement buildings on a 5 acre tract on Melrose and Western Sts., to cost about several million dollars. A. E. Curlett, 518 Merchants' Bank Bldg., Archt.

Cal., Reedley—The Bd. Educ. plans an election to vote on $400,000 bonds for a high school including a central heating plant. N. F. Marsh, 211 Bway., Central Bldg., Los Angeles, Archt.

Cal., Riverside — The Southern Sierras Power Co. plans to expend $2,183,329 for hydro-electric development, rebuilding distribution lines, increasing transformer capacity, extensions to sub-stations and additional telephone circuit. Engineer not selected.

Que., St. Angele de Laval—The Brown Pulp & Paper Co. plans to build a pulp and paper plant. About $1,500,000.

Ont., Kitchener — The Twin City Arena Co. plans to build an artificial ice rink and an ice plant. Refrigerating machinery for the manufacture of artificial ice will be required. About $250,000. Architect not appointed.

Ont., Ottawa—The Cecil Investment Co., 22 Sparks St., plans to build a hotel. About $1,000,000. Architect not appointed.

Ont., Ottawa—The Grey Nuns, Water St., appointed J. D. Chere, Archt., 163 Notre Dame St., Hull, Que., to prepare plans for a 3 story hospital here, including a vacuum steam heating system with ventilation apparatus. About $300 000.

Ont., Toronto—The City Council and the Board of Control have approved plans for a 3 story civic hospital including a vacuum steam heating system at Trinity Park here. About $400,000. W. Price, City Hall, Archt.

Alta., Calgary—Deputy Minister of Pub. Wks., L. C. Charlesworth, Edmonton, will receive bids until February 28 for a normal school and technical institute here, including a steam heating and ventilating system. About $500,000.

CONTRACTS AWARDED

N. Y., Brooklyn — Oppenheim & Collins, Fulton St., has awarded the contract for an addition to department store to C. A. Cowan & Co., 30 East 42nd St., New York City. A steam heating system will be installed in same. About $350,000.

N. Y., Glen Cove, L. I.—Tifereth Congregation will build a 1 story, 150 x 150 ft. synagogue and school including a steam heating system. About $300,000. Shampan & Shampan, 50 Court St., Brooklyn, Archts. and Engrs. Work will be done by day labor.

Tenn., Chattanooga—The Du Bois Rubber Tube Co., 1121 Ham. Natl. Bank, has awarded the contract for a rubber plant and a 42 x 50 ft., 300-hp. boiler house to Chickamauga Quarry & Constr. Co., James Bl.

Ky., Covington — R. Russel, Comr. of Public Property, has awarded the contract for a 10,000,000 gal. pump for the waterworks here, to Worthington Pump & Machinery Corp., Clinton and Roberts Sts., Buffalo, N. Y., at $196,900; for furnishing a 309-hp. boiler at $12,559 and a soot blower at $725, for the waterworks plant at Ft. Thomas, to D. Connolly Boiler Co.

O., Cleveland — The Bd. Educ., F. G. Hogan, Dir. East 6th St. and Rockwell Ave., has awarded the contract for the installation of a steam heating system in the school addition at East 146th St. and Kinsman Rd., to Warden & Leese Co., Prospect Ave., at $23,718. Noted Dec. 28.

Mich., Detroit—The Bd. Educ., 50 Bway. Ave., has awarded the contract for an addition to the high school at Cass and 2nd Aves., including addition to present building, new pump room and transformer room, to A. A. Albrecht & Co., Penobscot Bldg., at $1,523,000.

Wis., Tacheedah—The State Bd. of Control, Madison, has awarded contracts for power plant equipment at the Wisconsin Industrial Home for Women here, to Ridgway Dynamo & Engrg. Co., Marquette Bldg., Chicago, Ill., for generators, engines and balancers, $9,600; G. Rohn Electric Co., 524 Jackson St., Milwaukee, Wis., switchboard and distribution system, $6,250; H. P. Spaulding, 425 East Water St., Milwaukee, hot water convertors, $2,555; Chase-Gylstrom Co., 14 Wells St., Milwaukee, pumps, $2,198. Noted Dec. 28.

Wis., Wilton—The Wilton Canning Co. has awarded the contract for a 2 story, 60 x 85 ft. canning factory including a steam heating system, and a power house, to Hoeppner-Bartlett Co., 414 Grand Ave., E., Eau Claire. About $75,000.

Cal., Duarte—The Jewish Consumptive Relief Assn., c/o F. H. Wallis, Archt., 507 Title Insurance Bldg., Los Angeles, will build several buildings here, including a power plant. About $100,000. Work will be done by day labor.

Mont. Miles City—The Custer Co. Free High School, G. F. Ingersoll, Clk., awarded the contract for a steam heating and plumbing system to be installed in proposed high school on Center St., to F. G. Hatch, Hardin, at $45,000. Noted Jan. 4.

Mo., St. Louis — The U. S. Engineer's Office, War Dept., Washington, D. C., has awarded the contract for 6 return flue boilers for the Steamer Mississippi, to P. A. Rohan Boat Boiler & Tank Co., Marceau St., at $11,745.

Wash., Spokane—The Washington Water Power Co., has awarded the contract for power development, including power plant, dams, gates, penstock, etc., to Grant Smith & Co. 1505 Pioneer Bldg., St. Paul, Minn.

Cal. Los Angeles—The Orpheum Theatre Co., 630 South Bway., has awarded the contract for an 8 story theatre at 8th and Hill Sts., to McDonald & Kahn, 905 Washington Bldg. About $1,250,000.

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